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(54) **AUTONOMOUS VEHICLE CONTROL SYSTEM IMPLEMENTING TELEASSISTANCE**

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(57) **ABSTRACT**

An autonomous vehicle (AV) can dynamically analyze sensor data from a sensor suite to autonomously operate acceleration, braking, and steering systems along a current route. In analyzing the sensor data, the AV can determine a teleassist state requiring remote human assistance, and determine a plurality of decision options to resolve the teleassist state. The AV may then generate a teleassistance data package corresponding to the plurality of decision options, and transmit the teleassistance data package to a remote teleassistance system to enable a human operator to select one of the plurality of decision options for execution by the AV.

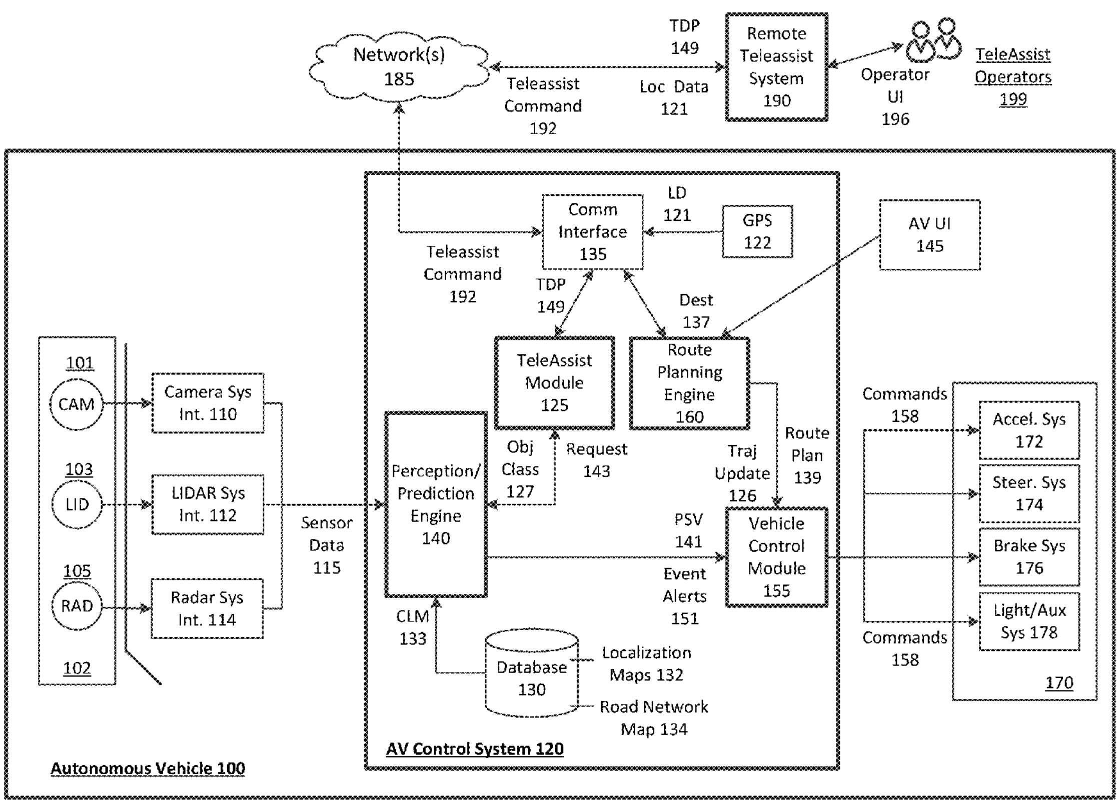
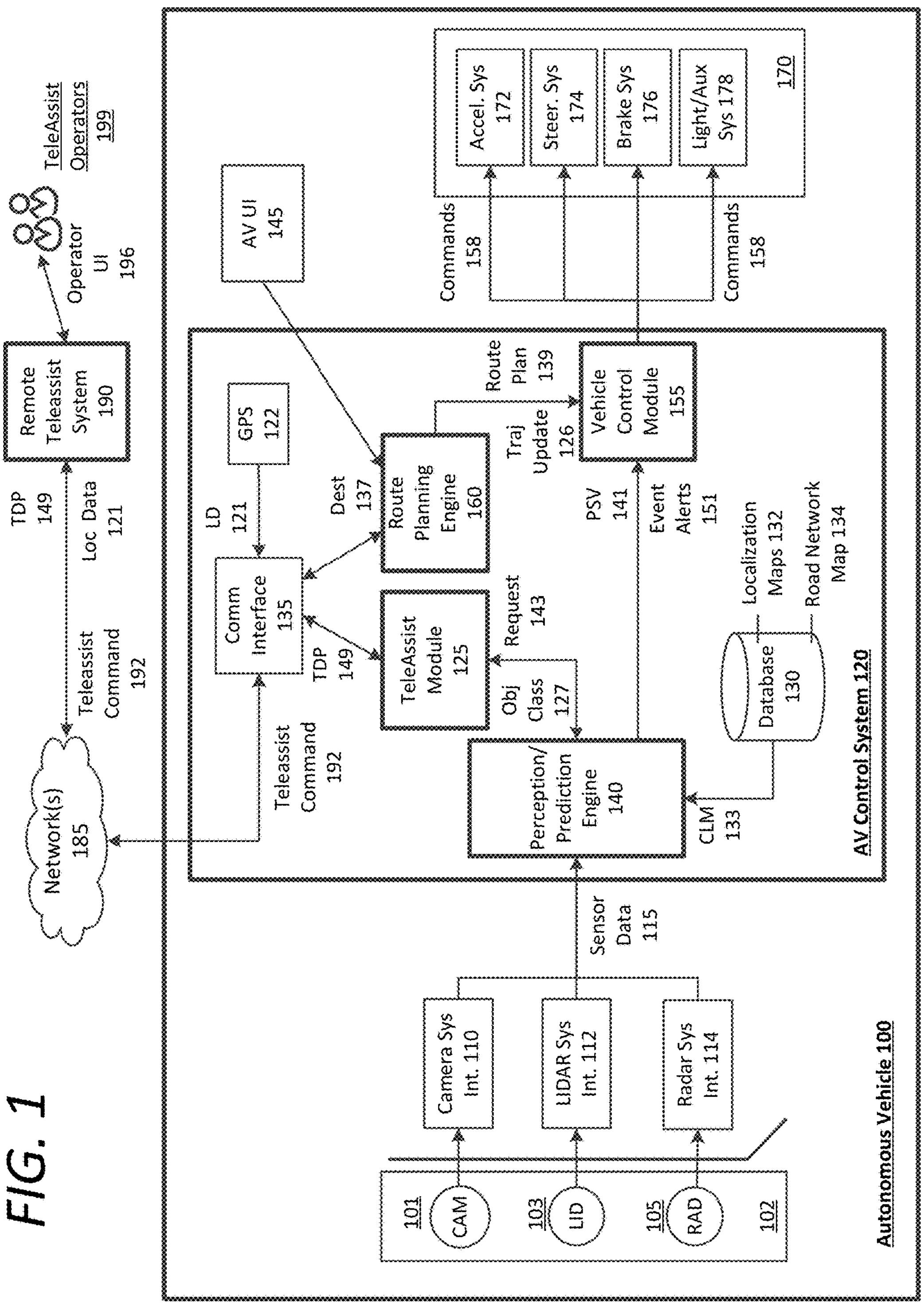
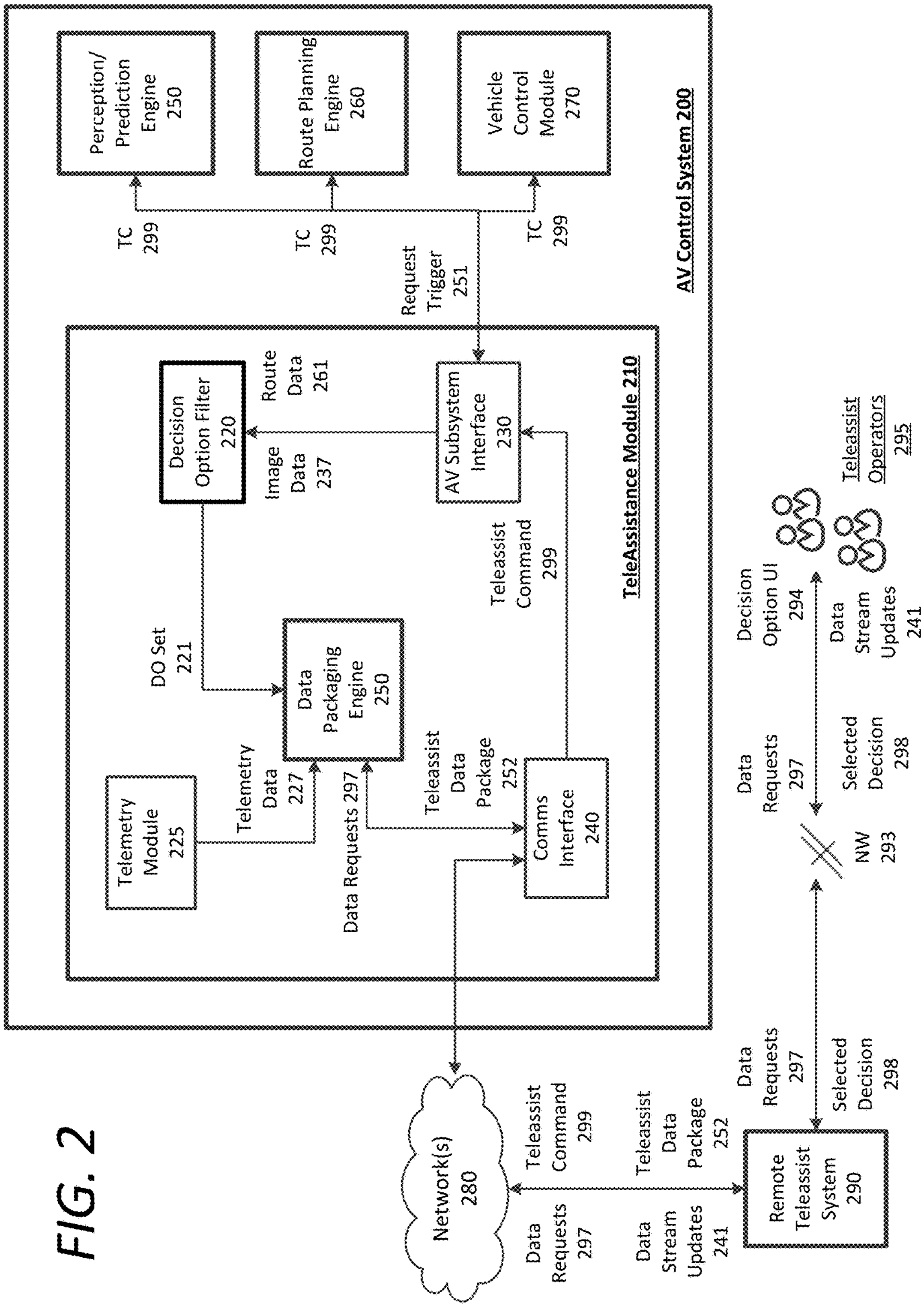


FIG. 1


TeleAssist Operators 199
Operator UI 196
Remote Teleassist System 190
TDP 149
Loc Data 121
Teleassist Command 192
Network(s) 185
Teleassist Command 192
AV UI 145
GPS 122
LD 121
Comm Interface 135
Dest 137
Route Planning Engine 160
Route Plan 139
Traj Update 126
Vehicle Control Module 155
TDP 149
TeleAssist Module 125
Request 143
Obj Class 127
PSV 141
Event Alerts 151
Perception/ Prediction Engine 140
CLM 133
Database 130
Localization Maps 132
Road Network Map 134
AV Control System 120
Commands 158
Commands 158
Accel. Sys 172
Steer. Sys 174
Brake Sys 176
Light/Aux Sys 178
170
Sensor Data 115
Camera Sys Int. 110
LIDAR Sys Int. 112
Radar Sys Int. 114
101
CAM
103
LID
105
RAD
102
Autonomous Vehicle 100


AV Control System 200
Perception/ Prediction Engine 250
Route Planning Engine 260
Vehicle Control Module 270
TC 299
TC 299
TC 299
Request Trigger 251
TeleAssistance Module 210
Decision Option Filter 220
Route Data 261
Image Data 237
AV Subsystem Interface 230
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Data Packaging Engine 250
Telemetry Module 225
Telemetry Data 227
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Teleassist Data Package 252
Comms Interface 240
Network(s) 280
Teleassist Command 299
Teleassist Data Package 252
Data Requests 297
Data Stream Updates 241
Remote Teleassist System 290
Data Requests 297
Selected Decision 298
NW 293
Data Requests 297
Selected Decision 298
Decision Option UI 294
Data Stream Updates 241
Teleassist Operators 295

FIG. 2

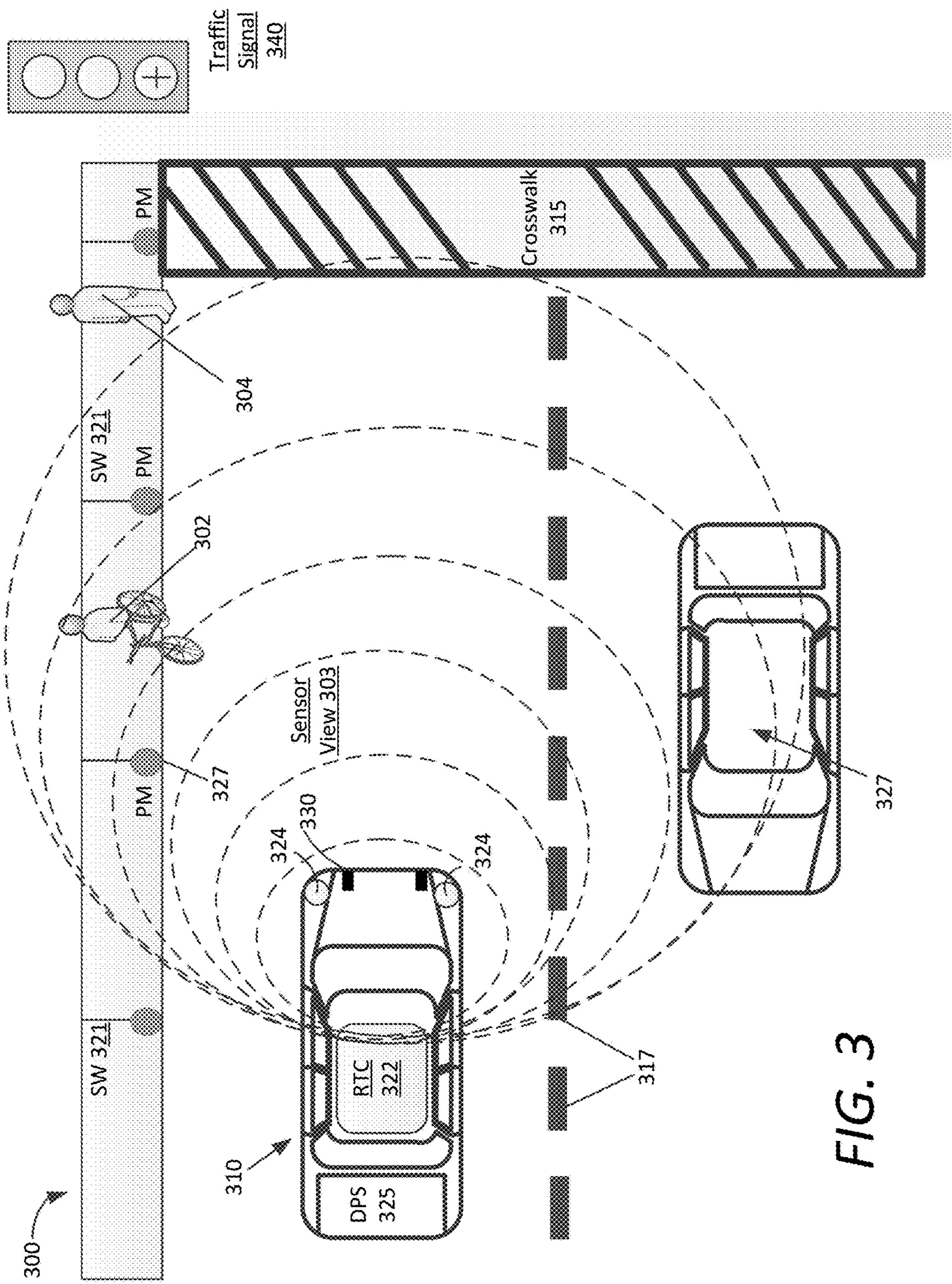

Traffic Signal 340
Crosswalk 315
PM
SW 321
PM
304
302
Sensor View 303
327
PM
330
324
324
327
SW 321
RTC 322
317
310
DPS 325
300

FIG. 3

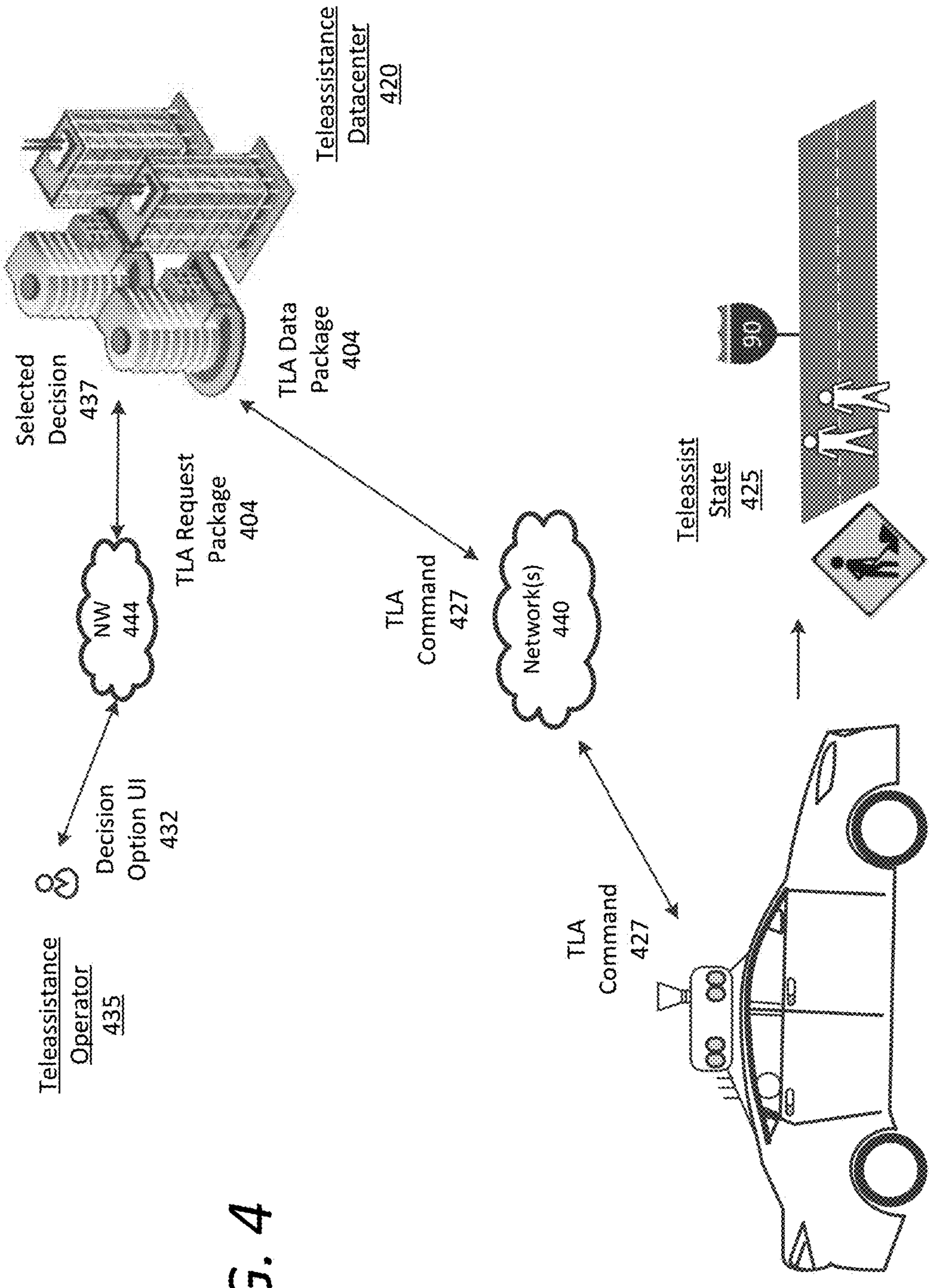

Teleassistance Datacenter 420
Selected Decision 437
TLA Data Package 404
TLA Request Package 404
NW 444
TLA Command 427
Network(s) 440
Teleassist State 425
90
Teleassistance Operator 435
Decision Option UI 432
TLA Command 427
AV 400

FIG. 4

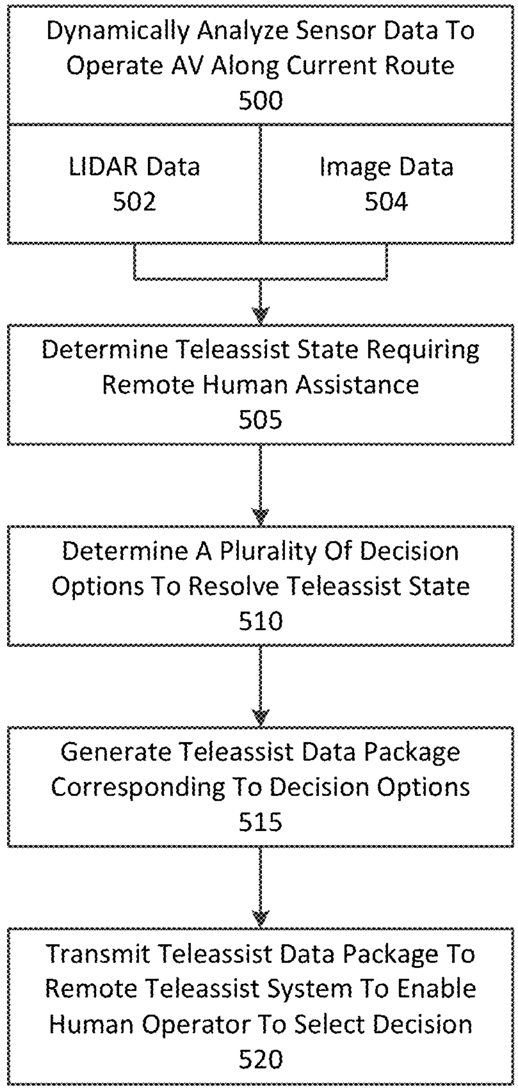

Dynamically Analyze Sensor Data To Operate AV Along Current Route 500
LIDAR Data 502
Image Data 504
Determine Teleassist State Requiring Remote Human Assistance 505
Determine A Plurality Of Decision Options To Resolve Teleassist State 510
Generate Teleassist Data Package Corresponding To Decision Options 515
Transmit Teleassist Data Package To Remote Teleassist System To Enable Human Operator To Select Decision 520

FIG. 5

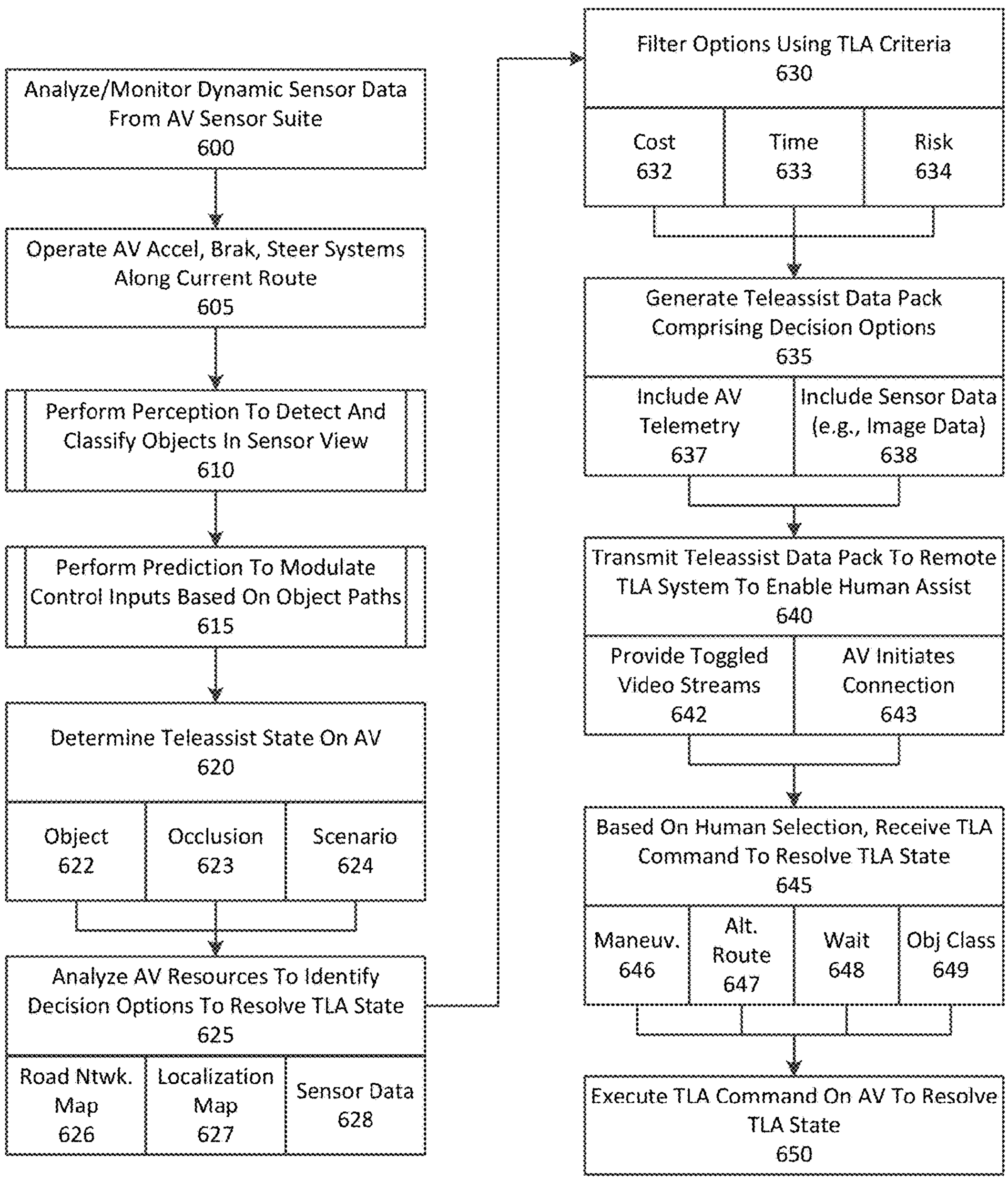

Analyze/Monitor Dynamic Sensor Data From AV Sensor Suite 600
Operate AV Accel, Brak, Steer Systems Along Current Route 605
Perform Perception To Detect And Classify Objects In Sensor View 610
Perform Prediction To Modulate Control Inputs Based On Object Paths 615
Determine Teleassist State On AV 620
Object 622
Occlusion 623
Scenario 624
Analyze AV Resources To Identify Decision Options To Resolve TLA State 625
Road Ntwk. Map 626
Localization Map 627
Sensor Data 628
Filter Options Using TLA Criteria 630
Cost 632
Time 633
Risk 634
Generate Teleassist Data Pack Comprising Decision Options 635
Include AV Telemetry 637
Include Sensor Data (e.g., Image Data) 638
Transmit Teleassist Data Pack To Remote TLA System To Enable Human Assist 640
Provide Toggled Video Streams 642
AV Initiates Connection 643
Based On Human Selection, Receive TLA Command To Resolve TLA State 645
Maneuv. 646
Alt. Route 647
Wait 648
Obj Class 649
Execute TLA Command On AV To Resolve TLA State 650

FIG. 6

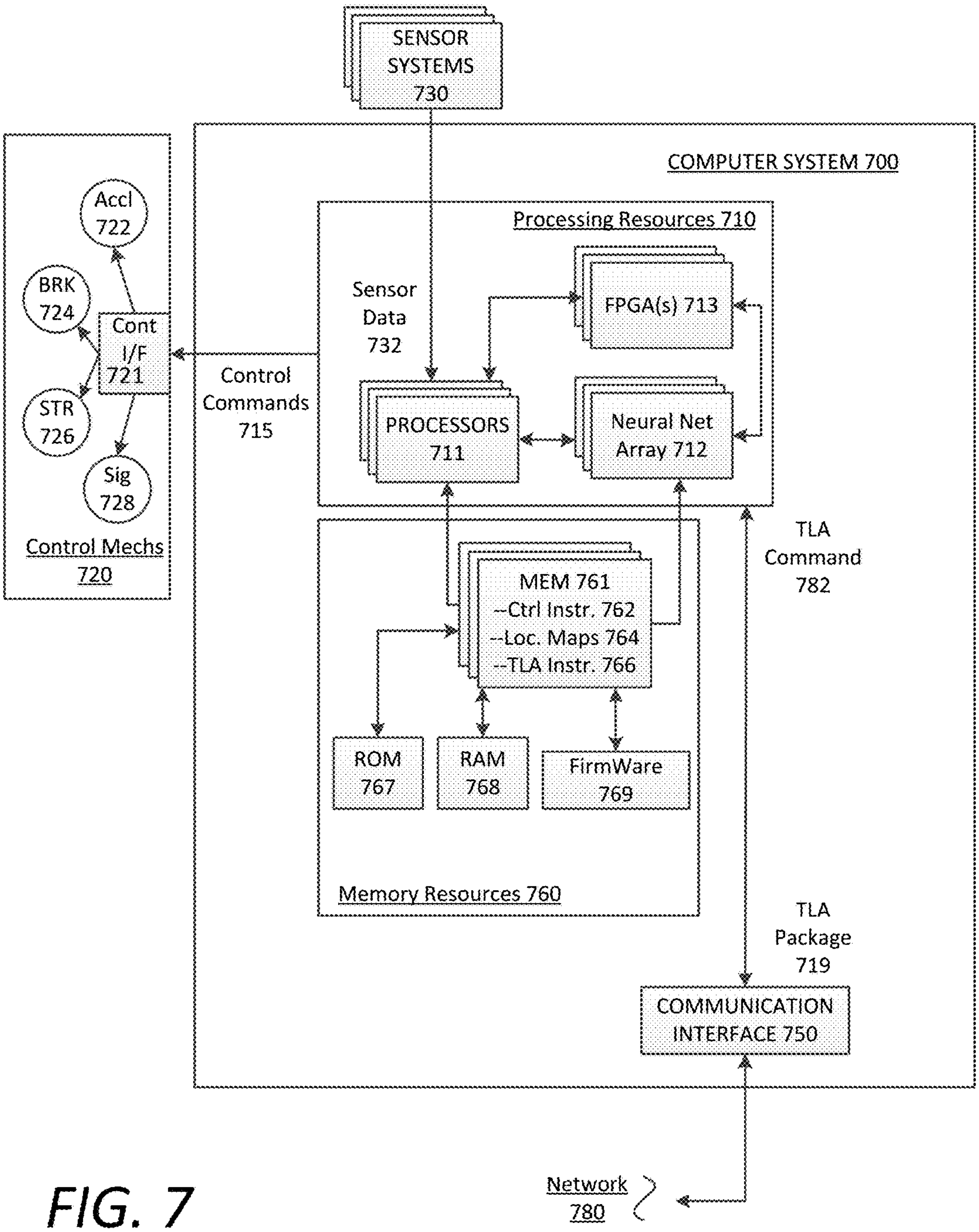
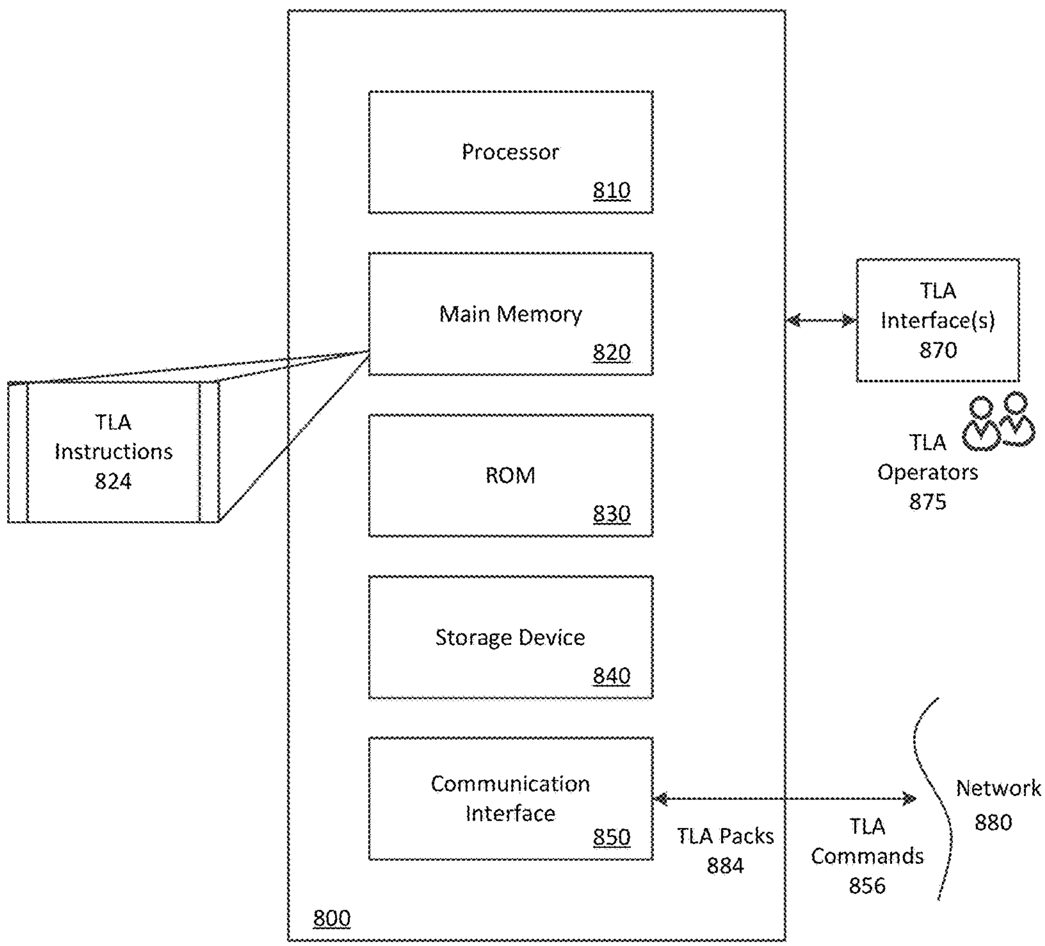

SENSOR SYSTEMS 730
COMPUTER SYSTEM 700
Processing Resources 710
Sensor Data 732
FPGA(s) 713
PROCESSORS 711
Neural Net Array 712
Accl 722
BRK 724
Cont I/F 721
STR 726
Sig 728
Control Mechs 720
Control Commands 715
TLA Command 782
MEM 761
--Ctrl Instr. 762
--Loc. Maps 764
--TLA Instr. 766
ROM 767
RAM 768
FirmWare 769
Memory Resources 760
TLA Package 719
COMMUNICATION INTERFACE 750
Network 780

FIG. 7



Processor
810
Main Memory
820
TLA
Instructions
824
ROM
830
Storage Device
840
Communication
Interface
850
800
TLA
Interface(s)
870
TLA
Operators
875
TLA Packs
884
TLA
Commands
856
Network
880

FIG. 8

AUTONOMOUS VEHICLE CONTROL SYSTEM IMPLEMENTING TELEASSISTANCE

BACKGROUND

[0001] The advancement of autonomous vehicle (AV) technology involves the safe transition from current programs requiring occasional on-board human intervention and awareness or full autonomy in test environments to enabling safe, fully-autonomous systems with capabilities equal to or greater than human drivers in virtually all driving scenarios. This transition towards "Level 5" autonomy entails the goal of removing human involvement entirely in the operation of the AV in typical and unexpected traffic scenarios on public roads and highways.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The disclosure herein is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like reference numerals refer to similar elements, and in which:

[0003] FIG. **1** is a block diagram illustrating an example autonomous vehicle operated by a control system implementing a teleassistance module, as described herein;

[0004] FIG. **2** is a block diagram illustrating an example teleassistance module utilized in connection with an autonomous vehicle, according to examples described herein;

[0005] FIG. **3** shows an example of an autonomous vehicle utilizing sensor data to navigate an environment in accordance with example implementations;

[0006] FIG. **4** shows an example autonomous vehicle initiating teleassistance, in accordance with example implementations;

[0007] FIG. **5** is a flow chart describing an example method of initiating teleassistance with a remote operator, according to examples described herein;

[0008] FIG. **6** is another flow chart describing an example method of initiating teleassistance with a remote operator, according to examples described herein;

[0009] FIG. **7** is a block diagram illustrating a computer system for an autonomous vehicle upon which examples described herein may be implemented; and

[0010] FIG. **8** is a block diagram illustrating a computer system for a backend datacenter upon which example transport systems described herein may be implemented.

DETAILED DESCRIPTION

[0011] An autonomous vehicle (AV) can include a sensor suite to generate a live sensor view of a surrounding area of the AV and acceleration, braking, and steering systems autonomously operated by a control system. In various implementations, the control system can dynamically analyze the sensor view of the surrounding area and a road network map, or a highly detailed localization map, in order to autonomously operate the acceleration, braking, and steering systems along a current route to a destination.

[0012] The control system can further execute an instruction set that causes that control system to dynamically analyze the sensor view to operate the acceleration, braking, and steering systems along a current route. In analyzing the sensor data, the control system can determine a teleassist state or situation requiring remote human assistance. The control system can then determine a plurality of decision options to resolve the teleassist state, and generate a teleassistance data package corresponding to the plurality of decision options. The control system may then transmit the teleassistance data package to a remote teleassistance system to enable a human operator to select one of the plurality of decision options.

[0013] In various implementations, the teleassist state can correspond to at least one of an occlusion, a blockage in the current route, or an indeterminate object. In some aspects, each of the plurality of decision options can comprise a manner in which to address the teleassist state. Additionally or alternatively, the control system of the AV can determine the plurality of decision options using a combination of map data and the sensor data from the sensor suite. In certain examples, the teleassistance data package can comprise at least one of telemetry data, a route plan corresponding to the current route, and image data from the sensor suite. For example, the image data comprises a video stream from one or more selected cameras of the sensor suite.

[0014] According to certain implementations, the control system can receive a response message from the remote teleassistance system indicating a selected decision option, by the human teleassistance operator from the plurality of decision options, and can control the acceleration, braking, and steering systems of the AV to execute the selected decision option. In some aspects, the selected decision option can correspond to one of a wait command, an ignore command, a maneuver command, or an alternate route command. In certain variations, the teleassistance data package can include data enabling the human operator to patch into a telemetry stream of the AV and one or more video streams from the sensor suite of AV. Additionally, the one or more video streams can correspond to individual camera systems of the sensor suite, and the teleassistance data package can enable the human operator to selectively toggle through video data from each of the individual camera systems of the AV.

[0015] Among other benefits, the examples described herein achieve a technical effect of enabling the AV to initiate teleassistance with a remote human operator and provide a number of alternative options determined on-board. This technical effect results in increased autonomy on the AV to advance machine learning and significantly reduce instances of teleassistance requests.

[0016] As used herein, a computing device refers to devices corresponding to desktop computers, cellular devices or smartphones, personal digital assistants (PDAs), laptop computers, tablet devices, virtual reality (VR) and/or augmented reality (AR) devices, wearable computing devices, television (IP Television), etc., that can provide network connectivity and processing resources for communicating with the system over a network. A computing device can also correspond to custom hardware, in-vehicle devices, or on-board computers, etc. The computing device can also operate a designated application configured to communicate with the network service.

[0017] One or more examples described herein provide that methods, techniques, and actions performed by a computing device are performed programmatically, or as a computer-implemented method. Programmatically, as used herein, means through the use of code or computer-executable instructions. These instructions can be stored in one or more memory resources of the computing device. A programmatically performed step may or may not be automatic.

[0018] One or more examples described herein can be implemented using programmatic modules, engines, or components. A programmatic module, engine, or component can include a program, a sub-routine, a portion of a program, or a software component or a hardware component capable of performing one or more stated tasks or functions. As used herein, a module or component can exist on a hardware component independently of other modules or components. Alternatively, a module or component can be a shared element or process of other modules, programs or machines.

[0019] Some examples described herein can generally require the use of computing devices, including processing and memory resources. For example, one or more examples described herein may be implemented, in whole or in part, on computing devices such as servers, desktop computers, cellular or smartphones, personal digital assistants (e.g., PDAs), laptop computers, virtual reality (VR) or augmented reality (AR) computers, network equipment (e.g., routers) and tablet devices. Memory, processing, and network resources may all be used in connection with the establishment, use, or performance of any example described herein (including with the performance of any method or with the implementation of any system).

[0020] Furthermore, one or more examples described herein may be implemented through the use of instructions that are executable by one or more processors. These instructions may be carried on a computer-readable medium. Machines shown or described with figures below provide examples of processing resources and computer-readable mediums on which instructions for implementing examples disclosed herein can be carried and/or executed. In particular, the numerous machines shown with examples of the invention include processors and various forms of memory for holding data and instructions. Examples of computer-readable mediums include permanent memory storage devices, such as hard drives on personal computers or servers. Other examples of computer storage mediums include portable storage units, such as CD or DVD units, flash memory (such as those carried on smartphones, multifunctional devices or tablets), and magnetic memory. Computers, terminals, network enabled devices (e.g., mobile devices, such as cell phones) are all examples of machines and devices that utilize processors, memory, and instructions stored on computer-readable mediums. Additionally, examples may be implemented in the form of computer-programs, or a computer usable carrier medium capable of carrying such a program.

[0021] As provided herein, the term "autonomous vehicle" (AV) describes any vehicle operating in a state of autonomous control with respect to acceleration, steering, braking, auxiliary controls (e.g., lights and directional signaling), and the like. Different levels of autonomy may exist with respect to AVs. For example, some vehicles may enable autonomous control in limited scenarios, such as on highways. More advanced AVs, such as those described herein, can operate in a variety of traffic environments without any human assistance. Accordingly, an "AV control system" can process sensor data from the AV's sensor array, and modulate acceleration, steering, and braking inputs to safely drive the AV along a given route.

[0022] System Description

[0023] FIG. **1** is a block diagram illustrating an example AV operated by a control system implementing a teleassistance module, as described herein. In an example of FIG. **1**, a control system **120** can autonomously operate the AV **100** in a given geographic region for a variety of purposes, including transport services (e.g., transport of humans, delivery services, etc.). In examples described, the AV **100** can operate without human control. For example, the AV **100** can autonomously steer, accelerate, shift, brake, and operate lighting components. Some variations also recognize that the AV **100** can switch between an autonomous mode, in which the AV control system **120** autonomously operates the AV **100**, and a manual mode in which a driver takes over manual control of the acceleration system **172**, steering system **174**, braking system **176**, and lighting and auxiliary systems **178** (e.g., directional signals and headlights).

[0024] According to some examples, the control system **120** can utilize specific sensor resources in order to autonomously operate the AV **100** in a variety of driving environments and conditions. For example, the control system **120** can operate the AV **100** by autonomously operating the steering, acceleration, and braking systems **172**, **174**, **176** of the AV **100** to a specified destination **137**. The control system **120** can perform vehicle control actions (e.g., braking, steering, accelerating) and route planning using sensor information, as well as other inputs (e.g., transmissions from remote or local human operators, network communication from other vehicles, etc.).

[0025] In an example of FIG. **1**, the control system **120** includes computational resources (e.g., processing cores and/or field programmable gate arrays (FPGAs)) which operate to process sensor data **115** received from a sensor system **102** of the AV **100** that provides a sensor view of a road segment upon which the AV **100** operates. The sensor data **115** can be used to determine actions which are to be performed by the AV **100** in order for the AV **100** to continue on a route to the destination **137**. In some variations, the control system **120** can include other functionality, such as wireless communication capabilities using a communication interface **135**, to send and/or receive wireless communications over one or more networks **185** with one or more remote sources. In controlling the AV **100**, the control system **120** can generate commands **158** to control the various control mechanisms **170** of the AV **100**, including the vehicle's acceleration system **172**, steering system **157**, braking system **176**, and auxiliary systems **178** (e.g., lights and directional signals).

[0026] The AV **100** can be equipped with multiple types of sensors **102** which can combine to provide a computerized perception, or sensor view, of the space and the physical environment surrounding the AV **100**. Likewise, the control system **120** can operate within the AV **100** to receive sensor data **115** from the sensor suite **102** and to control the various control mechanisms **170** in order to autonomously operate the AV **100**. For example, the control system **120** can analyze the sensor data **115** to generate low level commands **158** executable by the acceleration system **172**, steering system **157**, and braking system **176** of the AV **100**. Execution of the commands **158** by the control mechanisms **170** can result in throttle inputs, braking inputs, and steering inputs that collectively cause the AV **100** to operate along sequential road segments to a particular destination **137**.

[0027] In more detail, the sensor suite **102** operates to collectively obtain a sensor view for the AV **100** (e.g., in a forward operational direction, or providing a 360 degree sensor view), and to further obtain situational information proximate to the AV **100**, including any potential hazards or obstacles. By way of example, the sensors **102** can include multiple sets of camera systems **101** (video cameras, stereoscopic cameras or depth perception cameras, long range monocular cameras), LIDAR systems **103**, one or more radar systems **105**, and various other sensor resources such as sonar, proximity sensors, infrared sensors, and the like. According to examples provided herein, the sensors **102** can be arranged or grouped in a sensor system or array (e.g., in a sensor pod mounted to the roof of the AV **100**) comprising any number of LIDAR, radar, monocular camera, stereoscopic camera, sonar, infrared, or other active or passive sensor systems.

[0028] Each of the sensors **102** can communicate with the control system **120** utilizing a corresponding sensor interface **110**, **112**, **114**. Each of the sensor interfaces **110**, **112**, **114** can include, for example, hardware and/or other logical components which are coupled or otherwise provided with the respective sensor. For example, the sensors **102** can include a video camera and/or stereoscopic camera system **101** which continually generates image data of the physical environment of the AV **100**. The camera system **101** can provide the image data for the control system **120** via a camera system interface **110**. Likewise, the LIDAR system **103** can provide LIDAR data to the control system **120** via a LIDAR system interface **112**. Furthermore, as provided herein, radar data from the radar system **105** of the AV **100** can be provided to the control system **120** via a radar system interface **114**. In some examples, the sensor interfaces **110**, **112**, **114** can include dedicated processing resources, such as provided with field programmable gate arrays (FPGAs) which can, for example, receive and/or preprocess raw image data from the camera sensor.

[0029] In general, the sensor systems **102** collectively provide sensor data **115** to a perception/prediction engine **140** of the control system **120**. The perception/prediction engine **140** can access a database **130** comprising stored localization maps **132** of the given region in which the AV **100** operates. The localization maps **132** can comprise highly detailed ground truth data of each road segment of the given region. For example, the localization maps **132** can comprise prerecorded data (e.g., sensor data including image data, LIDAR data, and the like) by specialized mapping vehicles or other AVs with recording sensors and equipment, and can be processed to pinpoint various objects of interest (e.g., traffic signals, road signs, and other static objects). As the AV **100** travels along a given route, the perception/prediction engine **140** can access a current localization map **133** of a current road segment to compare the details of the current localization map **133** with the sensor data **115** in order to detect and classify any objects of interest, such as moving vehicles, pedestrians, bicyclists, and the like.

[0030] In various examples, the perception/prediction engine **140** can dynamically compare the live sensor data **115** from the AV's sensor systems **102** to the current localization map **133** as the AV **100** travels through a corresponding road segment. The perception/prediction engine **140** can flag or otherwise identify any objects of interest in the live sensor data **115** that can indicate a potential hazard. In accordance with many examples, the perception/prediction engine **140** can output a processed sensor view **141** indicating such objects of interest to a vehicle control module **155** of the AV **100**. In further examples, the perception/prediction engine **140** can predict a path of each object of interest and determine whether the AV control system **120** should respond or react accordingly. For example, the perception/prediction engine **140** can dynamically calculate a collision probability for each object of interest, and generate event alerts **151** if the collision probability exceeds a certain threshold. As described herein, such event alerts **151** can be processed by the vehicle control module **155** that generates control commands **158** executable by the various control mechanisms **170** of the AV **100**, such as the AV's acceleration, steering, and braking systems **172**, **174**, **176**.

[0031] On a higher level, the AV control system **120** can include a route planning engine **160** that provides the vehicle control module **155** with a route plan **139** and a travel trajectory **126** along a current route **139** to a destination **137**. The current route **139** may be determined by a backend transport system, or may be determined by the AV **100** via access to a local or external mapping service. In some aspects, the AV **100** can include a user interface **145**, such as a touch-screen panel or speech recognition features, which can enable a passenger to input a destination **137**. Additionally or alternatively, the AV control system **120** can include a communication interface **135** providing the AV **100** with connectivity to one or more networks **185**. In such implementations, the AV **100** may communicate with an on-demand transport system that manages routing of any number of AVs operating throughout a given region to provide transportation services to requesting riders. Thus, the route planning engine **160** may receive the destination **137** from the on-demand transport system over the network(s) **185** in order to plan a current route **139** for the AV **100**.

[0032] In mapping the current route **139**, the route planning engine **160** can generally utilize an on-board mapping engine or an external mapping service by transmitting map calls over the network(s) **185** in order to determine a most optimal route plan **139** from a current location of the AV **100** to the destination **137**. This route plan **139** may be determined based on distance, time, traffic conditions, additional pick-ups (e.g., for carpooling services), and the like. For each successive road segment on which the AV **100** travels, the route planning engine **160** can provide trajectory data to the vehicle control module **155** to enable the vehicle control module **155** to operate the AV **100** safely to the next road segment or the destination **137**. For example, the trajectory data can indicate that the vehicle control module **155** must change lanes or make a turn within the current localization map **133** in order to proceed to the next road segment along the current route plan **139**.

[0033] According to examples provided herein, the vehicle control module **155** can utilize the route plan **139**, the processed sensor view **141**, and event alerts **151** to autonomously operate the control mechanisms **170** of the AV **100**. As a basic example, to make a simple turn based on the route plan **139**, the vehicle control module **155** can generate control commands **158** that cause the lights and auxiliary systems **178** of the AV **100** to activate the appropriate directional signal, the braking system **176** to slow the AV **100** down for the turn, the steering system **174** to steer the AV **100** into the turn, and the acceleration system **172** to propel the AV **100** when exiting the turn. In further examples, event alerts **151** may indicate potential hazards such as a pedestrian crossing the road, a nearby bicyclist, obstacles on the road, a construction area, proximate vehicles, an upcoming traffic signal and signal state, and the like. The vehicle control module **155** can respond to each event alert **151** on a lower level while, on a higher level, operating the AV **100** along the determined route plan **139** using the processed sensor view **141**.

[0034] According to examples described herein, the control system **120** can include a teleassistance module **125** to enable remote human teleassistance operators **199** to aid the AV **100** in progressing along the route plan **139** when a teleassistance state or scenario is detected, or when the AV control system **120** encounters a "stuck" situation. As provided herein, the teleassistance state can comprise a detection anomaly in which the control system **120** has difficulty detecting objects (e.g., due to an occlusion), an identification or classification anomaly in which the perception/prediction engine **140** has difficulty classifying detected objects, a scenario in which the AV control system **120** is unable to make a safe decision (e.g., a crowded pedestrian area), or a fault condition corresponding to a diagnostics fault or failure of a component of the AV **100**, such as a computer, a mechanical component, or a sensor. In normal operation, a teleassistance state can cause the AV **100** to slow down, pull over, or stop while the AV control system **120** attempts to resolve the teleassistance state.

[0035] In various implementations, when a teleassistance state exists, the perception/prediction engine **140** can submit a teleassistance request **143** to the teleassistance module **125**. The teleassistance module **125** can treat the request **143** based on the type of teleassistance state to, for example, compile sensor data **115**, prioritize certain types of sensor data **115**, encode the sensor data **115** at different rates or qualities, specify an anomalous object in the sensor data **115** (e.g., using a bounding box), and/or incorporating telemetry, diagnostic data, and/or localization data (e.g., position and orientation of the AV **100**) with the inquiry **143**.

[0036] According to examples provided herein, based on the nature of the teleassistance state, the teleassistance module **125** can analyze the sensor data **115**, the current route plan **139**, a stored road network map **134** for the given region, and/or remotely accessible, live traffic data in order to determine a number of possible decision options for resolving the teleassistance state. In some examples, the teleassistance module **125** can determine the decision options based on a set of cost criteria, such as risk and time. In doing so, the teleassistance module **125** can compute the cost criteria for each of the potential options to determine whether to include the decision option in the set of decision options to be transmitted to remote teleassistance system **190**. For example, in order to be included in the set of decision options, the AV teleassistance module **125** may require that each decision option have a risk cost below a certain risk threshold, and/or have a time cost below a certain time threshold.

[0037] Accordingly, the teleassistance module **125** can determine the set of decision options available based on a cost assessment filter and compile or generate the set of decision options as a teleassistance data package **149**. The teleassistance data package **149** can include telemetry data (e.g., velocity, direction of travel, orientation, etc.) and specific sensor data **115** indicating each of the decision options. In some aspects, the teleassistance data package **149** can further include data enabling remote access to on-board sensor systems, such as individual camera or stereo-camera streams from the AV's **100** sensor suite **102**. Accordingly, the teleassist module **125** of the AV control system **120** can initiate the connection with the remote teleassist system **190**, and provide the teleassistance data package **149**, which can enable a teleassistance operator **199** to patch into or access the selected sensor data **115** or video streams from the AV's **100** sensor suite **102**.

[0038] Examples described herein recognize that network security for AVs **100** has been, and will be, an enduring concern in which certain procedures provide advantages to prevent unauthorized access from hackers or unscrupulous actors. According to examples described herein, the teleassistance module **125** can initiate the connection with the remote teleassistance system **190** to transmit the teleassistance data package **149**. In some aspects, the teleassistance module **125** can establish a unidirectional secure connection to transmit the teleassistance data package **149** to the remote teleassistance system **190**. Additionally or in variations, the teleassistance module **125** can securely access the remote teleassistance system **190** through virtual private network protocols, such as tunneling or certain encryption techniques in order to transmit the teleassistance data package **149**, and provide remote access to the AV's **100** sensor data streams.

[0039] In various examples, the AV control system **120** can further include a location-based resource, such as a GPS module **122** to provide location data **121** to the remote teleassistance system **190**. In various examples, the teleassistance data package **149** and the location data **121** can cause the teleassistance system **190** to generate an operator user interface **196** feature that enables a teleassistance operator **199** to quickly analyze each of the decision options supplied by the AV **100** and make a subjective selection of a most optimal decision option. As described in further detail herein, the operator user interface **196** can enable the teleassistance operator **199** to view relevant sensor data, location data **121**, and telemetry data in the teleassistance data package **149** to analyze the teleassistance state of the AV **100**.

[0040] In selecting a teleassistance operator **190**, the teleassistance system **190** can determine a first available operator **199** and provide the operator user interface **196** to that operator **199**. In certain implementations, the operator user interface **196** can enable the teleassistance operator **199** to toggle through individual video streams, via the teleassistance data package **149**, from individual cameras or groups of cameras on the AV's **100** sensor suite **102** in order to provide more context to the teleassistance state. In addition, the operator user interface **196** can provide a live connection to the AV control system **120** of the AV **100** to enable the teleassistance operator **199** to receive contextual information concerning the teleassistance state, and make a quick decision regarding the set of decision options in the teleassistance data package **149**.

[0041] Once the teleassistance operator **199** has selected a decision option on the operator user interface **196**, the teleassistance system **190** can generate a teleassistance command **192** corresponding to the selected decision option, and provide the teleassistance command **192** to the AV **100**. For example, the teleassistance system **190** can provide the teleassistance module **125** with access to the teleassistance command **192** over the network **185**, or can actively transmit the teleassistance command **192** to the communication interface **135** of the AV **100**. As described herein, the teleassistance command **192** can comprise a response message including an instruction to perform the selected decision by the teleassistance operator **199**. It is to be noted that the selected decision was determined by the AV **100** itself and grouped into a plurality of decision options in the teleassistance data package **149**. However, examples provided herein leverage the (current) significant advantages of human cognition to make the final decision. Such a system can provide vast amounts of decision data that can be used to "train" the AV control systems **120** (e.g., through software updates or deep learning techniques) of all AVs operating throughout a given region.

[0042] The teleassistance module **125** can process the teleassistance command **192** and generate a response to the source of the teleassistance state, depending on the cause of the teleassistance state. For example, if the perception/prediction engine **140** is unable to classify a detected object, the response message including the teleassistance command **192** can correspond to the classification of the indeterminate object **127**. Thus, the teleassistance module **125** can provide the object classification **127** of the indeterminate object to the perception/prediction engine **140**, which can complete the processed sensor view **141** (e.g., with the newly classified object **127**) for the vehicle control module **155**—or otherwise provide an event alert **151** if the classified object **127** comprises a hazard.

[0043] In variations, the teleassistance command **192** can comprise a maneuver command (e.g., maneuvering around a construction zone with caution), an ignore command, a wait command (e.g., in traffic accident scenarios), a command to proceed slowly with high caution, or an alternative route. Such commands can collectively comprise trajectory updates **126**, which can be provided to the vehicle control module **155** for execution. Such trajectory updates **126** can correspond directly to the selected decision option by the human teleassistance operator **199** from a set of decision options generated by the teleassistance module **125** of the AV **100**. Accordingly, the vehicle control module **155** can execute the trajectory update **126** by generating control commands **158** executable to modulate braking, steering, and acceleration inputs, and selectively initiating the lights and auxiliary systems **178** (e.g., signaling intent to other vehicles). Further description of the functions of the teleassistance module **125** is provided below with respect to FIG. **2**.

[0044] FIG. **2** is a block diagram illustrating an example teleassistance module utilized in connection with an autonomous vehicle, according to examples described herein. The AV control system **200** of FIG. **2** can correspond to the AV control system **120** of FIG. **1**. Furthermore, the teleassistance module **210**, perception/prediction engine **250**, route planning engine **260**, and vehicle control module **270** of FIG. **2** can correspond to the teleassistance module **125**, perception/prediction engine **140**, route planning engine **160**, and vehicle control module **155** shown and described with respect to FIG. **1**. Referring to FIG. **2**, any of the perception/prediction engine **250**, the route planning engine **260**, and the vehicle control module **270** can initiate a request trigger **251** to cause the teleassistance module **210** to generate a teleassistance data package **252** for remote teleassistance. The request trigger **251** can correspond to a teleassistance state in which the AV control system **200** is unable to resolve a certain anomaly, such as an indeterminate object, an occlusion in the sensor view, a closed road, a construction zone, a complex scenario (e.g., high pedestrian density, complex intersections, crowded bike lanes, etc.), and the like.

[0045] For example, the perception/prediction engine **250** can initiate a teleassist request trigger **251** when a sensor malfunctions or becomes misaligned, when there is a critical occlusion in the sensor view, or when it is unable to classify a detected object (e.g., a plastic bag in the AV's path). As another example, the route planning engine **260** can initiate a teleassist trigger **251** when the current route is blocked or the AV experiences a traffic jam. For example, the current route may include a blockage such as a construction zone, a closed road, a traffic incident or traffic jam, and the like. As yet another example, the vehicle control module **270** can initiate a teleassist request trigger when the vehicle diagnostics indicate an issue with the acceleration, braking, steering, shifting, or auxiliary systems (e.g., a low or flat tire, low oil pressure, low fuel or battery energy, overheating, etc.).

[0046] According to examples described herein, the teleassistance module **210** can include an AV subsystem interface **230** connecting the teleassistance module **210** with each of the perception/prediction engine **250**, the route planning engine **260**, and the vehicle control module **270**. Based on the request trigger **251**, the AV subsystem interface **230** can selectively provide image data **237** and/or route data **261** from the AV's sensor systems and/or route planning engine **260** to a decision option filter **220**. The decision option filter **220** can utilize the image data **237** and/or route data **261** to determine a plurality of decision options in light of the request trigger **251**. In other words, the request trigger **251** can indicate the nature of the teleassistance state of the control system **200**, which the decision option filter **220** can process in order to generate a decision option set **221** that includes a number of optimal actions that the AV control system **200** can perform to overcome the teleassistance state.

[0047] In determining each of the decision options in the set **221**, the decision option filter **220** can establish a set of criteria to filter out ineffective, burdensome, or costly options. For example, the decision option filter **220** can eliminate any options that have a time cost above a certain time threshold (e.g., five minutes) and/or a risk cost above a risk threshold. In doing so, the decision option filter **220** can analyze a road network map to identify any alternative routes, live traffic data to determine the increased ETA to the current destination, and the sensor data or processed sensor view to determine an immediate feasibility of each decision option (e.g., for low level maneuvers and U-turns). For indeterminate objects, the decision option filter **220** can also provide selected image data, from one or more specified cameras with the indeterminate object in the field of view, with the decision option set **221**. In further aspects, the decision option filter **220** can also provide diagnostics data of the AV as general information for the human teleassistance operator **295**.

[0048] The decision option filter **220** can transmit the decision option set **221** to a data packing engine **250** of the teleassistance module **210**. In certain implementations, the teleassistance module **210** can also include a telemetry module **225** that can provide telemetry data **227** comprising the current orientation, location, velocity, and/or trajectory of the AV. The data packing engine **250** can compile the relevant sensor data (e.g., image data, LIDAR data, video streams, etc.) for each decision option in the set **221**, the telemetry data **227**, and in some aspects, diagnostics data into a teleassistance request package **252** for transmission to the remote teleassistance system **290**. Accordingly, the teleassistance module **210** can include a communications interface **240** (e.g., the communications interface **135** shown in FIG. **1**) that enables the teleassistance module **210** to initiate a secure connection with the remote teleassistance system **290** over one or more networks **280**.

[0049] Upon receiving the teleassistance data package **252**, the remote teleassistance system **290** can identify an available operator **295** and generate a decision option user interface **294** for display on a teleassistance operator's **295** computing device (e.g., a personal computer) to enable the remote operator **295** to select from one of the plurality of decision options in the set **221**. In various implementations, the remote teleassistance system **290** can transmit the decision option user interface **294** to the available human teleassistance operator **295** over a local or wide area network **293**. The decision option user interface **294** can include each of the decision options in the set **221** determined by the decision option filter **220** of the teleassistance module **210**.

[0050] In certain aspects, the decision option user interface **294** enables the teleassistance operator **295** to selectively patch into the telemetry stream and/or sensor data stream from the AV control system **200** (e.g., using a personal computer or mobile computing device). For example, the teleassistance operator **295** may select certain request features on the decision option user interface **294** that cause a data request **297** to be generated and transmitted to the teleassistance module **210** via the remote teleassist system **290** and network(s) **280**, **293**. The data requests **297** can be processed by the data packaging engine **250** to provide the selected data stream update **241** back to the teleassistance operator **295** via the decision option user interface **294**. This enables the human teleassistance operator **295** to selectively review the image data **237** or video streams from individual cameras on the AV to generate more context regarding the teleassistance state.

[0051] Upon reviewing the decision option set **221** in the decision option user interface **294**, the teleassistance operator **295** can select a specified decision option **298** (e.g., via a user input or click input on the decision option user interface **294**). Data indicating the selected decision **298** may then be transmitted from the human teleassistance operator's **295** computing device to the remote teleassistance system **290**. Based on the selected decision **298**, the remote teleassistance system **290** can generate a teleassistance command **299** instructing the AV control system **200** to execute the selected decision option **298**. The remote teleassistance system **290** can transmit the teleassistance command **299** back to the teleassistance module **210** via the network(s) **280** and the communications interface **240**. Upon receiving the teleassistance command **299**, the communications interface **240** can relay or otherwise transmit the teleassistance command **299** to the AV subsystem interface **230**, which can provide the teleassistance command **299** to the relevant AV subsystem (e.g., the perception/prediction engine **250**, the route planning engine **260**, or the vehicle control module **270**) based on the nature of the teleassistance state.

[0052] Example teleassistance modules **210** in communication with a remote teleassistance system **290** can be distributed amongst any number of AVs operating throughout a given region (e.g., a metropolitan area managed by one or more datacenters, or a national level encompassing the whole of the United States). Accordingly, such a teleassistance mechanism can continue to leverage human cognition without the need of human assistance within the vehicle, and can contribute significantly to the transition into "Level 5" autonomy. It is contemplated that with continued progress in providing remote human teleassistance to AVs in predicted scenarios and in real-time will promote robustness in AV control systems, facilitating effectiveness in software updates and/or neural network learning.

[0053] Autonomous Vehicle in Operation

[0054] FIG. **3** shows an example of an AV utilizing sensor data to navigate an environment in accordance with example implementations. In an example of FIG. **3**, the autonomous vehicle **310** may include various sensors, such as a roof-top camera array (RTC) **322**, forward-facing cameras **324** and laser rangefinders **330**. In some aspects, a data processing system **325**, comprising a computer stack that includes a combination of one or more processors, FPGAs, and/or memory units, can be positioned in the cargo space of the vehicle **310**.

[0055] According to an example, the vehicle **310** uses one or more sensor views **303** (e.g., a stereoscopic or **3**D image of the environment **300**) to scan a road segment on which the vehicle **310** traverses. The vehicle **310** can process image data or sensor data, corresponding to the sensor views **303** from one or more sensors in order to detect objects that are, or may potentially be, in the path of the vehicle **310**. In an example shown, the detected objects include a bicyclist **302**, a pedestrian **304**, and another vehicle **327**—each of which may potentially cross into a road segment along which the vehicle **310** traverses. The vehicle **310** can use information about the road segment and/or image data from the sensor views **303** to determine that the road segment includes a divider **317** and an opposite lane, as well as a sidewalk (SW) **321**, and sidewalk structures such as parking meters (PM) **327**.

[0056] The vehicle **310** may determine the location, size, and/or distance of objects in the environment **300** based on the sensor view **303**. For example, the sensor views **303** may be **3**D sensor images that combine sensor data from the roof-top camera array **322**, front-facing cameras **324**, and/or laser rangefinders **330**. Accordingly, the vehicle **310** may accurately detect the presence of objects in the environment **300**, allowing the vehicle **310** to safely navigate the route while avoiding collisions with other objects.

[0057] According to examples, the vehicle **310** may determine a probability that one or more objects in the environment **300** will interfere or collide with the vehicle **310** along the vehicle's current path or route. In some aspects, the vehicle **310** may selectively perform an avoidance action based on the probability of collision. The avoidance actions may include velocity adjustments, lane aversion, roadway aversion (e.g., change lanes or drive further from the curb), light or horn actions, and other actions. In some aspects, the avoidance action may run counter to certain driving conventions and/or rules (e.g., allowing the vehicle **310** to drive across center line to create space for bicyclist).

[0058] The AV **310** can further detect certain road features that can increase the vehicle's alertness, such as a crosswalk **315** and a traffic signal **340**. In the example shown in FIG. **3**, the AV **310** can identify certain factors that can cause the vehicle **310** to enter a high alert state, such as the pedestrian **304** being proximate to the crosswalk **315** or the bicyclist **302** being on the road. Furthermore, the AV **310** can identify the signal state of the traffic signal **340** (e.g., green) to determine acceleration and/or braking inputs as the AV **310**

approaches the intersection. At any given time, the AV **310** can detect an anomaly—such as an indeterminate object or an issue with a sensor—and query a backend teleassistance system to resolve the anomaly.

[0059] According to examples described herein, the AV **310** may request remote teleassistance when, for example, the AV finds difficulty in proceeding safely. In the example shown in FIG. **3**, the AV **310** may identify the orientation of the bicyclist **302**, slow down, and request real-time teleassistance. In doing so, the AV **310** can generate a set of decision options to enable a remote, human operator to select from. A selected decision from the generated set may then be executed by the AV **310** in proceeding. In the example of FIG. **3**, the AV **310** may generate a set of decision options that include stopping and waiting until the bicyclist passes, ignoring the bicyclist, slowing and proceeding with caution, sounding the horn, or any combination of the foregoing. In response, the human teleassistance operator may select "slow and proceed with caution," allowing the AV **310** to proceed accordingly and with and added layer of confidence.

[0060] FIG. **4** shows an example autonomous vehicle initiating teleassistance, in accordance with example implementations. In the example shown in FIG. **4**, an AV **400** approaches a location or scenario that causes a teleassist state **425** on the AV **400**. In general, the teleassist state **425** can cause the AV **400** to slow down or stop due to safety, uncertainty (e.g., below a threshold), a set of criteria not being met to proceed (e.g., collision probability being exceeded, object uncertainty, or an anomalous situation, such as a road construction zone or pedestrians on the road, as shown). Based on the teleassistance state **425**, the AV **400** can generate and transmit a teleassistance data package **404** over one or more networks **440** to a remote teleassistance datacenter **420** implementing a teleassistance system described herein. As further described herein, the teleassistance data package **404** can include a plurality of decision options determined by the AV **400**, such as maneuvering around the pedestrians, turning the AV **400** around or following an alternate route, sounding the horn, proceeding slowly with asserted caution, and the like.

[0061] The teleassistance datacenter **420** can generate a decision option user interface **432** based on the teleassistance data package **404**, which can include each of the decision options identified by the AV **400**. As provided herein, the teleassistance datacenter **420** can connect with teleassistance operators over a local or non-local network **444**. The teleassistance datacenter **420** can provide each of the decision options on a generated user interface **432** to an available human teleassistance operator **435**. As described herein, the operator **435** can review the decision option user interface **432** and subjectively select what the operator **435** believes to be the most optimal option on the user interface **432**. Data indicating the selected decision **437** may be transmitted back to the teleassistance datacenter **420**, enabling the teleassistance datacenter **420** to generate a teleassistance command **427** corresponding to the selected decision **437**. The teleassistance datacenter **420** may then transmit the teleassistance command **427** back to the AV **400** over the network(s) **440**. the AV **400** may then execute the teleassistance command **427** to overcome or resolve the teleassistance state **425**.

[0062] Methodology

[0063] FIGS. **5** and **6** are flow charts describing example methods of initiating teleassistance with a remote operator, according to examples described herein. In the below descriptions of FIGS. **5** and **6**, reference may be made to reference characters representing like features shown and described with respect to FIGS. **1** and **2**. Furthermore, the steps and processes described with respect to FIGS. **5** and **6** below may be performed by an example autonomous vehicle (AV) **100** or AV control system **120**, **200**, as described herein with respect to FIGS. **1** and **2**. Referring to FIG. **5**, the AV control system **120** can dynamically analyze sensor data **115** to operate the AV **100** along a current route **139** (**500**). In doing so, the AV control system **120** can process real-time LIDAR data (**502**) and/or image data (**504**) to perform object detection and prediction operations.

[0064] In various examples, the AV control system **120** can determine a teleassistance state requiring remote human assistance, as described herein (**505**). Based on the teleassistance state, the AV control system **120** can determine a plurality of decision options to resolve or overcome the teleassistance state (**510**). The AV control system **120** may then generate a teleassistance data package **149** comprising the plurality of decision options (**515**). The AV control system **120** may then transmit the teleassistance data package **149** to the remote teleassistance system **190** to enable a human operator **199** to select a decision from the set of decision options identified by the AV control system **120** (**520**).

[0065] FIG. **6** is a lower level flow chart describing an example method of initiating remote teleassistance by an AV. Referring to FIG. **6**, the AV control system **120** can analyze and/or monitor dynamic sensor data **115** from the sensor suite **102** of the AV **100** (**600**). Based on the sensor data **115**, the AV control system **120** can operate the AV's **100** acceleration **172**, braking, **176**, and steering systems **174** along a current route **139** (**605**). In doing so, the AV control system **120** can perform perception operations to detect and classify objects of interest in the sensor view, such as pedestrians, bicyclists, other vehicles, and the like (**610**). Additionally, the AV control system **120** can perform prediction operations for each of the objects of interest to modulate control inputs on the various control mechanisms **170** of the AV **100** (**615**).

[0066] In various examples, the AV control system **120** can determine or otherwise identify a teleassistance state on the AV **100** (**620**) As described throughout, the teleassistance state can correspond to an indeterminate object (**622**), and occlusion in the sensor view (e.g., a misalignment, debris, a large truck, foliage, etc.) (**623**), or any number of scenarios described herein (**624**). The AV control system **120** may then analyze various AV resources to identify decision options to resolve or overcome the teleassistance state (**625**). Such AV resources can include a road network map **134** to identify any number of alternative routes (**626**), the current localization map **133** (**627**), and/or the sensor data **115** from the AV's sensor suite **102** (**628**).

[0067] In many examples, the AV control system **120** can filter the decision options using a set of teleassistance criteria, or otherwise rank the options (**630**). For example, the AV control system **120** can assess an overall cost for each of the decision options (**632**), which can include a time cost (**633**), and a risk cost (**634**). In some aspects, the AV control system **120** can limit the number of decision options to a predetermine number (e.g., the top three options). The AV control system **120** may then generate a teleassistance data package **149** comprising the decision options (**635**). In some aspects, the teleassistance data package **149** can also include telemetry data **227** of the AV **100** (**637**), and can further include select sensor data **115** relevant to the teleassistance state (**638**).

[0068] The AV control system **120** may then transmit the teleassistance data package **149** to the remote teleassistance system **190** to enable human assistance (**640**). In some examples, the teleassistance data package **149** can provide toggled video streams that enable a human teleassistance operator **199** to toggle through each camera or group of cameras (**642**). As described herein, the AV control system **120** can initiate the connection to transmit the teleassistance data package **149** (e.g., establishing a unidirectional connection, a virtual private network, encrypted communications, etc.) (**643**). Thereafter, the human teleassistance operator **199** can select one of the decision options, and data indicating the selection can be processed by the remote teleassistance system **190**.

[0069] Based on the selection by the human operator **199**, the AV control system **120** can receive a teleassistance command **192** to resolve or overcome the teleassistance state (**645**). As described, the teleassistance command **192** can correspond directly to one of the decision options identified or determined by the AV **100**. The teleassistance command **192** can thus instruct the AV control system **120** to perform a maneuver (**646**), take an alternative route (**647**), wait or ignore the teleassistance state (**648**), and/or classify an indeterminate object for perception and prediction operations (**649**). The AV control system **120** may then execute the teleassistance command **192** and resolve or overcome the teleassistance state (**650**).

[0070] Hardware Diagrams

[0071] FIG. **7** is a block diagram illustrating a computer system upon which example AV processing systems described herein may be implemented. The computer system **700** can be implemented using a number of processing resources **710**, which can comprise processors **711**, field programmable gate arrays (FPGAs) **713**. In some aspects, any number of processors **711** and/or FPGAs **713** of the computer system **700** can be utilized as components of a neural network array **712** implementing a machine learning model and utilizing road network maps stored in memory **761** of the computer system **700**. In the context of FIGS. **1** and **2**, various aspects and components of the AV control system **120**, **200**, can be implemented using one or more components of the computer system **700** shown in FIG. **7**.

[0072] According to some examples, the computer system **700** may be implemented within an autonomous vehicle (AV) with software and hardware resources such as described with examples of FIGS. **1** and **2**. In an example shown, the computer system **700** can be distributed spatially into various regions of the AV, with various aspects integrated with other components of the AV itself. For example, the processing resources **710** and/or memory resources **760** can be provided in a cargo space of the AV. The various processing resources **710** of the computer system **700** can also execute control instructions **762** using microprocessors **711**, FPGAs **713**, a neural network array **712**, or any combination of the same.

[0073] In an example of FIG. **7**, the computer system **700** can include a communication interface **750** that can enable communications over a network **780**. In one implementation, the communication interface **750** can also provide a data bus or other local links to electro-mechanical interfaces of the vehicle, such as wireless or wired links to and from control mechanisms **720** (e.g., via a control interface **721**), sensor systems **730**, and can further provide a network link to a backend transport management system or a remote teleassistance system (implemented on one or more datacenters) over one or more networks **780**.

[0074] The memory resources **760** can include, for example, main memory **761**, a read-only memory (ROM) **767**, storage device, and cache resources. The main memory **761** of memory resources **760** can include random access memory (RAM) **768** or other dynamic storage device, for storing information and instructions which are executable by the processing resources **710** of the computer system **700**. The processing resources **710** can execute instructions for processing information stored with the main memory **761** of the memory resources **760**. The main memory **761** can also store temporary variables or other intermediate information which can be used during execution of instructions by the processing resources **710**. The memory resources **760** can also include ROM **767** or other static storage device for storing static information and instructions for the processing resources **710**. The memory resources **760** can also include other forms of memory devices and components, such as a magnetic disk or optical disk, for purpose of storing information and instructions for use by the processing resources **710**. The computer system **700** can further be implemented using any combination of volatile and/or non-volatile memory, such as flash memory, PROM, EPROM, EEPROM (e.g., storing firmware **769**), DRAM, cache resources, hard disk drives, and/or solid state drives.

[0075] The memory **761** may also store localization maps **764** in which the processing resources **710**—executing the control instructions **762**—continuously compare to sensor data **732** from the various sensor systems **730** of the AV. Execution of the control instructions **762** can cause the processing resources **710** to generate control commands **715** in order to autonomously operate the AV's acceleration **722**, braking **724**, steering **726**, and signaling systems **728** (collectively, the control mechanisms **720**). Thus, in executing the control instructions **762**, the processing resources **710** can receive sensor data **732** from the sensor systems **730**, dynamically compare the sensor data **732** to a current localization map **764**, and generate control commands **715** for operative control over the acceleration, steering, and braking of the AV. The processing resources **710** may then transmit the control commands **715** to one or more control interfaces **721** of the control mechanisms **720** to autonomously operate the AV through road traffic on roads and highways, as described throughout the present disclosure.

[0076] The memory **761** may also store teleassistance instructions **766** that the processing resources **710** can execute to identify detection or object anomalies, and transmit teleassistance data packages **719** to a backend teleassistance system over the network **780**, and receive a teleassistance command **784** in return. Execution of the instructions **762**, **764**, **766** can cause the processing resources **710** to process the teleassistance commands **784** accordingly to resolve the detected teleassistance state. Thereafter, the processing resources **710** can generate control commands **715** to cause the control mechanisms **720** to autonomously operate the AV along the current route or an alternate route accordingly.

[0077] FIG. **8** is a block diagram that illustrates a computer system upon which examples described herein may be implemented. A computer system **800** can be implemented on, for example, a server or combination of servers. For example, the computer system **800** may be implemented as part of a network service for providing transportation services. In the context of FIGS. **1** and **2**, the teleassistance system **190**, **290** may be implemented using a computer system **800** such as described by FIG. **8**.

[0078] In one implementation, the computer system **800** includes processing resources **810**, a main memory **820**, a read-only memory (ROM) **830**, a storage device **840**, and a communication interface **850**. The computer system **800** includes at least one processor **810** for processing information stored in the main memory **820**, such as provided by a random access memory (RAM) or other dynamic storage device, for storing information and instructions which are executable by the processor **810**. The main memory **820** also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by the processor **810**. The computer system **800** may also include the ROM **830** or other static storage device for storing static information and instructions for the processor **810**. A storage device **840**, such as a magnetic disk or optical disk, is provided for storing information and instructions.

[0079] The communication interface **850** enables the computer system **800** to communicate over one or more networks **880** (e.g., cellular network) through use of the network link (wireless or wired). Using the network link, the computer system **800** can communicate with one or more computing devices, one or more servers, and/or one or more autonomous vehicles. The executable instructions stored in the memory **820** can include teleassistance instructions **824**, which enables the computer system **800** to receive teleassistance data packages **884** from AVs operating throughout the given region. In some aspects, execution of the teleassistance instructions **824** can cause the computer system **800** to automatically generate a teleassistance command **856**. In addition or as a variation, the computer system **800** can transmit the teleassistance data packages **884** over one or more teleassistance interfaces **870** to human teleassistance operators **875**, which can cause the teleassistance commands **856** to be generated and then transmitted back to the AVs in order to resolve teleassistance states or scenarios.

[0080] The processor **810** is configured with software and/or other logic to perform one or more processes, steps and other functions described with implementations, such as described with respect to FIGS. **1-6**, and elsewhere in the present application. Examples described herein are related to the use of the computer system **800** for implementing the techniques described herein. According to one example, those techniques are performed by the computer system **800** in response to the processor **810** executing one or more sequences of one or more instructions contained in the main memory **820**. Such instructions may be read into the main memory **820** from another machine-readable medium, such as the storage device **840**. Execution of the sequences of instructions contained in the main memory **820** causes the processor **810** to perform the process steps described herein. In alternative implementations, hard-wired circuitry may be used in place of or in combination with software instructions to implement examples described herein. Thus, the examples described are not limited to any specific combination of hardware circuitry and software.

[0081] It is contemplated for examples described herein to extend to individual elements and concepts described herein, independently of other concepts, ideas or systems, as well as for examples to include combinations of elements recited anywhere in this application. Although examples are described in detail herein with reference to the accompanying drawings, it is to be understood that the concepts are not limited to those precise examples. As such, many modifications and variations will be apparent to practitioners skilled in this art. Accordingly, it is intended that the scope of the concepts be defined by the following claims and their equivalents. Furthermore, it is contemplated that a particular feature described either individually or as part of an example can be combined with other individually described features, or parts of other examples, even if the other features and examples make no mention of the particular feature. Thus, the absence of describing combinations should not preclude claiming rights to such combinations.

What is claimed is:

1. An autonomous vehicle (AV) comprising:

a sensor suite generating sensor data of a surrounding environment of the AV;

acceleration, braking, and steering systems; and

a control system executing an instruction set that causes that control system to:

dynamically analyze the sensor data to operate the acceleration, braking, and steering systems along a current route;

in analyzing the sensor data, determine a teleassist state requiring remote human assistance;

determine a plurality of decision options to resolve the teleassist state;

generate a teleassistance data package corresponding to the plurality of decision options; and

transmit the teleassistance data package to a remote teleassistance system to enable a human operator to select one of the plurality of decision options.

2. The AV of claim **1**, wherein the teleassist state corresponds to at least one of an occlusion, a blockage in the current route, or an indeterminate object.

3. The AV of claim **1**, wherein each of the plurality of decision options comprises a manner in which to address the teleassist state, and wherein the executed instruction set causes the control system to determine the plurality of decision options using a combination of map data and the sensor data from the sensor suite.

4. The AV of claim **1**, wherein the teleassistance data package comprises telemetry data, a route plan corresponding to the current route, and image data from the sensor suite.

5. The AV of claim **4**, wherein the image data comprises a video stream from one or more selected cameras of the sensor suite.

6. The AV of claim **1**, wherein the executed instruction set further causes the control system to:

receive a response message from the remote teleassistance system indicating a selected decision option from the plurality of decision options; and

control the acceleration, braking, and steering systems of the AV to execute the selected decision option.

7. The AV of claim **6**, wherein the selected decision option corresponds to one of a wait command, an ignore command, a maneuver command, or an alternate route command.

8. The AV of claim **1**, wherein the teleassistance data package includes data enabling the human operator to patch into a telemetry stream of the AV and one or more video streams from the sensor suite of AV.

9. The AV of claim **8**, wherein the one or more video streams correspond to individual camera systems of the sensor suite, and wherein the teleassistance data package enables the human operator to selectively toggle through video data from each of the individual camera systems.

10. The AV of claim **1**, wherein the executed instruction set causes the control system to determine the plurality of decision options by identifying

11. A computer-implemented method of initiating teleassistance, the method being performed by one or more processors of an autonomous vehicle (AV) and comprising:

dynamically analyzing sensor data from a sensor suite of the AV to operate a acceleration, braking, and steering systems of the AV along a current route;

in analyzing the sensor data, determining a teleassist state requiring remote human assistance;

determining a plurality of decision options to resolve the teleassist state;

generating a teleassistance data package corresponding to the plurality of decision options; and

transmitting the teleassistance data package to a remote teleassistance system to enable a human operator to select one of the plurality of decision options.

12. The method of claim **11**, wherein the teleassist state corresponds to at least one of an occlusion, a blockage in the current route, or an indeterminate object.

13. The method of claim **11**, wherein each of the plurality of decision options comprises a manner in which to address the teleassist state, and wherein the executed instruction set causes the control system to determine the plurality of decision options using a combination of map data and the sensor data from the sensor suite.

14. The method of claim **11**, wherein the teleassistance data package comprises telemetry data, a route plan corresponding to the current route, and image data from the sensor suite.

15. The method of claim **14**, wherein the image data comprises a video stream from one or more selected cameras of the sensor suite.

16. The method of claim **11**, further comprising:

receiving a response message from the remote teleassistance system indicating a selected decision option from the plurality of decision options; and

controlling the acceleration, braking, and steering systems of the AV to execute the selected decision option.

17. The method of claim **16**, wherein the selected decision option corresponds to one of a wait command, an ignore command, a maneuver command, or an alternate route command.

18. The method of claim **11**, wherein the teleassistance data package includes data enabling the human operator to patch into a telemetry stream of the AV and one or more video streams from the sensor suite of AV.

19. The method of claim **18**, wherein the one or more video streams correspond to individual camera systems of the sensor suite, and wherein the teleassistance data package enables the human operator to selectively toggle through video data from each of the individual camera systems.

20. A non-transitory computer readable medium storing instructions that, when executed by one or more processors of an autonomous vehicle (AV), cause the AV to:

dynamically analyze sensor data from a sensor suite of the AV to operate acceleration, braking, and steering systems of the AV along a current route;

in analyzing the sensor data, determine a teleassist state requiring remote human assistance;

determine a plurality of decision options to resolve the teleassist state;

generate a teleassistance data package corresponding to the plurality of decision options; and

transmit the teleassistance data package to a remote teleassistance system to enable a human operator to select one of the plurality of decision options.

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