AUTONOMOUS AND USER CONTROLLED VEHICLE SUMMON TO A TARGET

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of, and claims priority to, U.S. Patent App. No. 16/272,273 titled "AUTONOMOUS AND USER CONTROLLED VEHICLE SUMMON TO A TARGET" and filed on February 11, 2019, the disclosure of which is hereby incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] Human drivers are typically required to operate vehicles and the driving tasks performed by them are often complex and can be exhausting. For example, retrieving or summoning a parked car from a crowded parking lot or garage can be inconvenient and tedious. The maneuver often involves walking towards one's vehicle, three-point turns, edging out of tight spots without touching neighboring vehicles or walls, and driving towards a location that one previously came from. Although some vehicles are capable of being remotely operated, the route driven by the vehicle is typically limited to a single straight-line path in either the forwards or reverse direction with limited steering range and no intelligence in navigating the vehicle along its own path.

SUMMARY

[0002a] In an example, the present disclosure refers to a system, comprising: a processor configured to: one or more sensors configured to generate sensor data by capturing an environment surrounding a vehicle; receive an identification of a geographical location associated with a target specified by a user remote from the vehicle; utilize a machine learning model trained by training data to generate a representation of the environment surrounding the vehicle, the representation of the environment surrounding the vehicle comprising a drivable space predicted by the machine learning model based on the sensor data, wherein the training

data is prepared before the sensor data is generated and the drivable space is used for calculating a cost metric associated with the cost of traversing through a location in the environment surrounding the vehicle; calculate at least a portion of a path to a target location corresponding to the received geographical location using the representation of the environment surrounding the vehicle; and provide at least one command to automatically navigate the vehicle based on the determined path and updated sensor data from at least a portion of the one or more sensors of the vehicle; and a memory coupled to the processor and configured to provide the processor with instructions.

[0002b] In an example, the present disclosure refers to a method comprising: using one or more sensors to generate sensor data by capturing an environment surrounding a vehicle; receiving an identification of a geographical location associated with a target specified by a user remote from the vehicle; utilizing a trained machine learning model to generate a representation of the environment surrounding the vehicle, the representation of the environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on the sensor data, wherein the drivable space is used for calculating a cost metric associated with the cost of traversing through a location in the environment surrounding the vehicle; calculating at least a portion of a path to a target location corresponding to the received geographical location using the representation of the environment surrounding the vehicle; and providing at least one command to automatically navigate the vehicle based on the determined path and updated sensor data from at least a portion of the one or more sensors of the vehicle.

[0002c] In an example, the present disclosure refers to a computer program product, the computer program product being embodied in a non-transitory computer readable storage medium and comprising computer instructions for: receiving an identification of a geographical location associated with a target specified by a user remote from a vehicle; utilizing a neural network as part of a trained machine learning model to generate a representation of at least a portion of an environment surrounding the vehicle, the representation of the environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on sensor data generated by one or more sensors, wherein the drivable space is used for calculating a cost metric associated with the cost of traversing through a location in the environment surrounding the vehicle; calculating at least a portion of a path to a target location

corresponding to the received geographical location using the representation of the environment surrounding the vehicle; and providing at least one command to automatically navigate the vehicle based on the determined path and updated sensor data from at least a portion of the one or more sensors of the vehicle.

[0002d] In an aspect, the present disclosure refers to a system, comprising:

one or more sensors configured to generate sensor data by capturing a real-time world environment surrounding a vehicle;

a processor configured to:

receive an identification of a geographical location associated with a target specified by a user remote from the vehicle;

utilize a machine learning model trained by training data to generate a representation of the real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the machine learning model based on the sensor data, wherein the training data is prepared before the sensor data is generated and the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the one or more drivability values;

calculate at least a portion of a path to a target location corresponding to the geographical location using the representation of the real-world environment surrounding the vehicle; and

provide at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one

or more sensors of the vehicle; and

a memory coupled to the processor and configured to provide the processor with instructions.

[0002e] In an aspect, the present disclosure refers to a method comprising:

using one or more sensors to generate sensor data by capturing a real-world environment surrounding a vehicle;

receiving an identification of a geographical location associated with a target specified by a user remote from the vehicle;

utilizing a trained machine learning model to generate a representation of the real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on the sensor data, wherein the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the drivability value;

calculating at least a portion of a path to a target location corresponding to the geographical location using the representation of the real-world environment surrounding the vehicle; and

providing at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one or more sensors of the vehicle.

[0002f]In an aspect, the present disclosure refers to a computer program product, the computer program product being embodied in a non-transitory computer readable storage medium and

comprising computer instructions for:

receiving an identification of a geographical location associated with a target specified by a user remote from a vehicle;

utilizing a neural network as part of a trained machine learning model to generate a representation of a real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on sensor data generated by one or more sensors, wherein the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the drivability value;

calculating at least a portion of a path to a target location corresponding to the geographical location using the representation of the real-world environment surrounding the vehicle; and

providing at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one or more sensors of the vehicle.

[0003] One example includes a system. The system comprises a processor configured to: receive an identification of a geographical location associated with a target specified by a user remote from a vehicle; utilize a machine learning model to generate a representation of at least a portion of an environment surrounding the vehicle using sensor data from one or more sensors of the vehicle; calculate at least a portion of a path to a target location corresponding to the received geographical location using the generated representation of the at least portion of the

environment surrounding the vehicle; and provide at least one command to automatically navigate the vehicle based on the determined path and updated sensor data from at

WHAT IS CLAIMED IS:

1. A system, comprising:

one or more sensors configured to generate sensor data by capturing a real-time world environment surrounding a vehicle;

a processor configured to:

receive an identification of a geographical location associated with a target specified by a user remote from the vehicle;

utilize a machine learning model trained by training data to generate a representation of the real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the machine learning model based on the sensor data, wherein the training data is prepared before the sensor data is generated and the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the one or more drivability values;

calculate at least a portion of a path to a target location corresponding to the geographical location using the representation of the real-world environment surrounding the vehicle; and

provide at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one or more sensors of the vehicle; and

a memory coupled to the processor and configured to provide the processor with instructions.

2. The system of claim 1, wherein the target specified by the user is a dynamically updated current location of a mobile device of the user.

3. The system of claims 1-2, wherein the geographical location is based on a global positioning system location detected by a mobile device of the user.

4. The system of claim 1, wherein the target specified by the user indicates a target orientation of the vehicle.

5. The system of claim 1, wherein the target is specified on a map by the user.

6. The system of claim 1, wherein the user selected the target within a limited geographical region within a threshold distance from a detected location of a device utilized by the user to specify the target.

7. The system of claim 1, wherein the user selected the target within a limited geographical region associated with a current location of the vehicle.

8. The system of claim 1, wherein an ability for the user to specify the target is enabled based on a determination that a location of a device of the user is within a threshold distance from a current location of the vehicle.

9. The system of claims 1-8, wherein automatically navigating the vehicle is aborted in response to a determination that a heartbeat signal has not been received from a device of the user.

10. The system of claims 1-8, wherein automatically navigating the vehicle is paused in response to a detection of an obstacle using an ultrasonic sensor.

11. The system of claims 1-10, wherein a speed of the vehicle during automatically navigating the vehicle is limited to be equal or less than a specified limit.

12. The system of claims 1-11, wherein the target location is dynamically updated based on a periodically updated geographical location of a device of the user.

13. The system of claims 1-12, wherein the one or more sensors of the vehicle include a plurality of cameras.

14. The system of claims 1-13, wherein the representation of the at least a portion of the real-world environment is generated using auxiliary sensor data obtained using one or more of an ultrasonic sensor or a radar sensor.

15. The system of claims 1-14, wherein the processor is further configured to receive a specified target time associated with the target specified by the user.

16. The system of claims 1-15, wherein the representation of the at least a portion of the real-world environment surrounding the vehicle includes a three-dimensional representation of the portion of the real-world environment.

17. The system of claims 1-16, wherein the target location is determined including by determining whether the geographical location of the target is a valid location to be occupied by the vehicle.

18. The system of claims 1-17, wherein the target location is determined based on the sensor data from the one or more sensors.

19. A method, comprising:

using one or more sensors to generate sensor data by capturing a real-world environment surrounding a vehicle;

receiving an identification of a geographical location associated with a target specified by a user remote from the vehicle;

utilizing a trained machine learning model to generate a representation of the real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on the sensor data, wherein the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the drivability value;

calculating at least a portion of a path to a target location corresponding to the

geographical location using the representation of the real-world environment surrounding the vehicle; and

providing at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one or more sensors of the vehicle.

20. A computer program product, the computer program product being embodied in a non-transitory computer readable storage medium and comprising computer instructions for:

receiving an identification of a geographical location associated with a target specified by a user remote from a vehicle;

utilizing a neural network as part of a trained machine learning model to generate a representation of a real-world environment surrounding the vehicle, the representation of the real-world environment surrounding the vehicle comprising a drivable space predicted by the trained machine learning model based on sensor data generated by one or more sensors, wherein the drivable space is used for calculating a cost metric associated with a cost of traversing through a location in the real-world environment surrounding the vehicle,

wherein the representation of the real-world environment surrounding the vehicle comprises an occupancy grid which includes one or more drivability values at each grid location of a plurality of grid locations which form respective portions of the occupancy grid, each grid location corresponding to a location in the real-world environment,

wherein a drivability value at a grid location represents a probability that a corresponding location in the real-world environment is drivable and is selected from a range of drivability values,

wherein the cost metric is calculated based on the drivability value;

calculating at least a portion of a path to a target location corresponding to the geographical location using the representation of the real-world environment surrounding the vehicle; and

providing at least one command to automatically navigate the vehicle based on the at least the portion of the path and updated sensor data from at least a portion of the one or more sensors of the vehicle.