Claims

1. A monitoring system for a traffic control system, the traffic control system including a plurality of traffic lights, the monitoring system comprising:

an inbound interface component configured to receive a stream of sensor data from a plurality of visual sensors, each visual sensor being configured to capture light signals of the plurality of traffic lights, each traffic light being sensed by at least one of the visual sensors, and the received stream of sensor data being representative of a current signal status of each of the plurality of traffic lights;

an analytics component configured to predict at least one future signal status for at least one of the plurality of traffic lights based on use of a machine learning algorithm applied to data for a current signal status associated with the at least one of the plurality of traffic lights and data for a previously received signal status associated with the at least one of the plurality of traffic lights, the at least one future signal status including an expected point in time when the current signal status will switch to the at least one future signal status; and

an outbound status provisioning component configured to send at least one message to a vehicle, the at least one message including the current signal status and the at least one future signal status of the predicted at least one of the plurality of traffic lights, the sent at least one message configured to influence operation of the vehicle.

2. The monitoring system of claim 1, wherein the plurality of visual sensors includes at least one digital camera with a field of view including at least one of the plurality of traffic lights.

3. The monitoring system of claim 1, wherein the plurality of visual sensors includes at least one photocell mounted on a respective traffic light included in the plurality of traffic lights, the at least one photocell configured to measure light emitted by the respective traffic light.

4. The monitoring system of claim 1, wherein the visual sensor is associated with a lane specific traffic light.

5. The monitoring system of claim 1, wherein the at least one message sent to the vehicle includes data relevant for at least one of a SPaT or a MAP application executed by the vehicle.

6. The monitoring system of claim 1, wherein the inbound interface component is further configured to:

duplicate the stream of sensor data, and

delay the stream of sensor data or the duplicate stream of sensor data; and

wherein the analytics component is further configured to:

use the delayed stream of sensor data as a training stream for the machine learning algorithm, and

use the non-delayed stream of sensor data for prediction of signal status changes.

7. The monitoring system of claim 1,

wherein the inbound interface component is further configured to generate, from the received stream of sensor data, another stream of sensor data including signal status data at equidistant time intervals, and

wherein multiple consecutive time intervals included in the signal status data form a data frame, the data frame being suitable as input data for the machine learning algorithm.

8. The monitoring system of claim 1,

wherein the inbound interface component is further configured to receive another stream of sensor data from a plurality of other sensors, each of the other sensors being associated with a respective traffic light and including a traffic status for the associated respective traffic light, and the traffic status being an indicator for current traffic affected by the associated respective traffic light; and

wherein the analytics component is further configured to:

receive the traffic status for the associated respective traffic light, and

use the received traffic status in the machine learning algorithm for the prediction of the future signal status for the associated respective traffic light.

9. The monitoring system of claim 1,

wherein the inbound interface component is further configured to receive, from a traffic management system, traffic light program data for at least one of the plurality of traffic lights, the traffic light program data including information about at least one program controlling light signal switching of the respective at least one of the plurality of traffic lights, and

wherein the analytics component is further configured to use the received traffic light program data in the machine learning algorithm for the prediction of the future signal status of the respective at least one of the plurality of traffic lights.

10. A computer-implemented method for monitoring a traffic control system, the traffic control system including a plurality of traffic lights, the method comprising:

receiving a stream of sensor data from a plurality of visual sensors, each visual sensor being configured to capture light signals of the plurality of traffic lights, each traffic light being sensed by at least one of the visual sensors, and the received stream of sensor data being representative of a current signal status of each of the plurality of traffic lights;

predicting at least one future signal status for at least one of the plurality of traffic lights based on use of a machine learning algorithm applied to data for a current signal status associated with the at least one of the plurality of traffic lights and data for a previously received signal status associated with the at least one of the plurality of traffic lights, the at least one future signal status including an expected point in time when the current signal status will switch to the at least one future signal status; and

sending at least one message to a vehicle, the at least one message including the current signal status and the predicted at least one future signal status of the at least one of the plurality of traffic lights, the sent at least one message configured to influence operation of the vehicle.

11. The method of claim 10, wherein the received stream of sensor data originates from at least one digital camera with a field of view including at least one of the traffic lights.

12. The method of claim 10, wherein the received stream of sensor data originates from at least one photocell mounted on a respective traffic light included in the plurality of traffic lights, the at least one photocell configured to measure the light emitted by the respective traffic light.

13. The method of claim 10, wherein the at least one message includes lane specific status data configured to influence the operation of the vehicle in a respective lane.

14. The method of claim 10,

wherein receiving a stream of sensor data from a plurality of visual sensors further includes:

duplicating the stream of sensor data; and

delaying the stream of sensor data or the duplicate stream of sensor data; and

wherein predicting at least one future signal status for at least one of the plurality of traffic lights further includes:

using the delayed stream of sensor data as a training stream for the machine learning algorithm, and

using the non-delayed stream of sensor data for prediction of signal status changes.

15. The method of claim 10,

wherein receiving a stream of sensor data from a plurality of visual sensors further includes receiving another stream of sensor data from a plurality of other sensors, each of the other sensors being associated with a respective traffic light and including data for a traffic status for the associated respective traffic light, and data for the traffic status being an indicator for current traffic affected by the associated respective traffic light; and

wherein predicting at least one future signal status for at least one of the plurality of traffic lights further includes using the data for the traffic status in the machine learning algorithm for the prediction of the future signal status for the associated respective traffic light.

16. A non-transitory computer program product having computer-readable instructions that when loaded into a memory of a monitoring system for a traffic control system and executed by at least one processor of the monitoring system performs the steps of:

receiving a stream of sensor data from a plurality of visual sensors, each visual sensor being configured to capture light signals of a plurality of traffic lights, each traffic light being sensed by at least one of the visual sensors, and the received stream of sensor data being representative of a current signal status of each of the plurality of traffic lights;

predicting at least one future signal status for at least one of the plurality of traffic lights based on use of a machine learning algorithm applied to data for a current signal status associated with the at least one of the plurality of traffic lights and data for a previously received signal status associated with the at least one of the plurality of traffic lights, the at least one future signal status including an expected point in time when the current signal status will switch to the at least one future signal status; and

sending at least one message to a vehicle, the at least one message including the current signal status and the predicted at least one future signal status of the at least one of the plurality of traffic lights, the sent at least one message configured to influence operation of the vehicle.

17. The non-transitory computer program product of claim 16, wherein the received stream of sensor data originates from at least one digital camera with a field of view including at least one of the traffic lights.

18. The non-transitory computer program product of claim 16, wherein the received stream of sensor data originates from at least one photocell mounted on a respective traffic light included in the plurality of traffic lights, the at least one photocell configured to measure the light emitted by the respective traffic light.

19. The non-transitory computer program product of claim 16, comprising further instructions to perform the steps of:

duplicating the stream of sensor data; and

delaying the stream of sensor data or the duplicate stream of sensor data; and

wherein predicting at least one future signal status for at least one of the plurality of traffic lights further includes:

using the delayed stream of sensor data as a training stream for the machine learning algorithm, and

using the non-delayed stream of sensor data for prediction of signal status changes.

20. The non-transitory computer program product of claim 16,

wherein receiving a stream of sensor data from a plurality of visual sensors further includes receiving another stream of sensor data from a plurality of other sensors, each of the other sensors being associated with a respective traffic light and including data for a traffic status for the associated respective traffic light, and the data for the traffic status being an indicator for current traffic affected by the associated respective traffic light; and

wherein predicting at least one future signal status for at least one of the plurality of traffic lights further includes using the data for the traffic status in the machine learning algorithm for the prediction of the future signal status for the associated respective traffic light.