

CLAIMS

1. A computer-implemented method for predicting taxi demand, the method comprising
generating, by a three-dimensional spatiotemporal model, a current demand
count for a plurality of unit grids based on a current taxi dataset comprising
current demand and supply of a taxi fleet, wherein the three-dimensional
spatiotemporal model comprises a convolutional neural network trained on a
first dataset of demand and supply of taxis at the plurality of unit grids over a
plurality of time periods to output a demand count, wherein the first dataset is
encoded as a plurality of three-dimensional images, and each three-
dimensional image represents one unit grid over the plurality of time periods;
generating, by a micro-movement model, a current micro-movement modifier,
wherein the current micro-movement modifier reflects a current probability of
taxi demand in a plurality of road links based on the current taxi dataset
comprising current elapsed time of most recent vacant taxi for the road links
and current summary statistics of trips in the road links, wherein the micro-
movement model is trained on a second dataset of elapsed time of most recent
vacant taxi for the road links and summary statistics of trips in the road links
to correlate a probability of taxi demand in the road links to an elapsed time of
most recent vacant taxi in the road links and to output a micro-movement
modifier reflecting the probability of taxi demand in the road links, wherein the
road links are adjacent to form a region; and
generating, by an integrating neural network, a current combined taxi demand
prediction value based on the current demand count and the current micro-
movement modifier, wherein the integrating neural network is trained to
combine and assign weightage on the demand count and the micro-movement
modifier.
2. The method according to claim 1 wherein each three-dimensional image is a
 $K \times K \times h$ image, wherein h represents a number of historical time period, K
represents a size of a neighbourhood proximate to the unit grid, and each pixel
in the three-dimensional image has dimensions (x, y, m) , where (x, y) refer to
a coordinate of the unit grid and m refers to a specific time period.

3. The method according to claim 2 wherein data of each pixel is stored in three channels respectively encoding the number of trips originating in the coordinate of the unit grid, the number of trips ending in the coordinate of the unit grid, and the number of vacant taxis observed in the unit grid in the specific time period.

~~4. The method according to any of claims 1 to 3 further comprising generating, by a micro-movement model, a current micro-movement modifier, wherein the current micro-movement modifier reflects a current probability of taxi demand in a plurality of road links based on the current taxi dataset comprising current elapsed time of most recent vacant taxi for the road links and current summary statistics of trips in the road links, wherein the micro-movement model is trained on a second dataset of elapsed time of most recent vacant taxi for the road links and summary statistics of trips in the road links to correlate a probability of taxi demand in the road links to an elapsed time of most recent vacant taxi in the road links and to output a micro-movement modifier reflecting the probability of taxi demand in the road links, wherein the road links are adjacent to form a region; and generating, by an integrating neural network, a current combined taxi demand prediction value based on the current demand count and the current micro-movement modifier, wherein the integrating neural network is trained to combine and assign weightage on the demand count and the micro-movement modifier.~~

5.4. The method according to any one of claims 1 to 3-4 wherein the micro-movement model comprises at least two stacked Long Short-Term Memory (LSTM) networks.

6.5. The method according to any of claims ~~4 to 5~~ 1 to 4 further comprising generating, by a hybrid LSTM-TCN model, a current exogenous taxi demand modifier based on both the current taxi dataset and additional dataset comprising current exogenous factors, wherein the hybrid LSTM-TCN model comprises at least two LSTM networks and a temporal convolutional network

(TCN) trained on the first dataset and a third dataset of exogenous factors to output an exogenous taxi demand modifier, wherein the exogenous taxi demand modifier quantifies how exogenous factors affect demand and supply of taxis,

5 wherein generating, by the integrating neural network, the current combined taxi demand prediction value includes generating, by the integrating neural network, the current combined taxi demand prediction value based on the current demand count, the current micro-movement modifier and the current exogenous taxi demand modifier,

10 wherein the integrating neural network is further trained to combine and assign weightage on the exogenous taxi demand modifier.

7.6. The method according to claim ~~6-5~~ wherein the current taxi dataset and additional dataset is provided to the at least two LSTM networks and outputs
15 from the LSTM networks serve as inputs to the TCN to output the current exogenous taxi demand modifier.

8.7. The method according to any of claims ~~6-5~~ to ~~7-6~~ wherein the exogenous factors are selected from the following: meteorological conditions in the time
20 period, temporal data in the time period and taxi-related data in the time period.

9.8. The method according to any of claims 1 to ~~8-7~~ wherein the current taxi dataset comprises a current taxi location, and the method further comprises identifying
25 at least one unit grid or road link with taxi demand proximal to the current taxi location based on the current demand count or the current combined taxi demand prediction value.

~~10-9~~.9. The method according to claim ~~9-8~~ further comprising generating a personalised recommendation for an individual taxi driver based on the current
30 demand count or the current combined taxi demand prediction value and location of vacant taxis.

~~11.10.~~ A non-transitory computer readable medium comprising instructions which, when executed on a computer, cause the computer to perform the method according to any of claims 1 to ~~109~~.

- 5 ~~12.11.~~ A driver guidance system comprising a taxi prediction module, and a taxi coordination module communicably coupled thereto,
the taxi prediction module comprises a three-dimensional spatiotemporal model, a micro-movement model and an integrating neural network, the three-dimensional spatiotemporal model comprises a convolutional neural network
10 trained on a first dataset of demand and supply of taxis at a plurality of unit grids over a plurality of time periods to output a demand count, wherein the first dataset is encoded as a plurality of three-dimensional images, and each three-dimensional image represents one unit grid over the plurality of time periods, wherein the three-dimensional spatiotemporal model is configured to
15 generate a current demand count for the plurality of unit grids based on a current taxi dataset comprising current demand and supply of a taxi fleet, and the taxi coordination module is configured to provide personalised recommendations to an individual taxi driver based on the current demand count for the plurality of grid locations,
20 wherein the micro-movement model is trained on a second dataset of elapsed time of most recent vacant taxi for a plurality of road links of the unit grids and summary statistics of trips in the plurality of road links to correlate a probability of taxi demand in the road links to an elapsed time of most recent vacant taxi in the road links and output a micro-movement modifier reflecting the probability of taxi demand in the road links, wherein the road links are adjacent to form a region;
25 the integrating neural network is trained to combine and assign weightage on the demand count and the micro-movement modifier to generate a combined taxi demand prediction value,
30 wherein the taxi prediction module is further configured to generate, by the micro-movement model, a current micro-movement modifier, wherein the current micro-movement modifier reflects a current probability of taxi demand in the road links based on the current taxi dataset and to generate, by the integrating neural network, a current combined taxi demand prediction value

based on the current demand count and the current micro-movement modifier;
and
wherein the taxi coordination module is configured to provide personalised
recommendations to the individual taxi driver based on the current demand
count for the plurality of grid locations includes the taxi coordination module is
configured to provide personalised recommendations to the individual driver
based on the current combined taxi demand prediction value for the plurality
of grid locations.

13-12. The driver guidance system according to claim 12-11 wherein each three-dimensional image is a $K \times K \times h$ image, wherein h represents a number of historical time period, K represents a size of a neighbourhood proximate to the unit grid, and each pixel in the three-dimensional image has dimensions (x, y, m) , where (x, y) refer to a coordinate of the grid location and m refers to a specific time period.

14-13. The driver guidance system according to claim 13-12 wherein data of each pixel is stored in three channels respectively encoding the number of trips originating in the coordinate of the grid location, the number of trips ending in the coordinate of the grid location, and the number of vacant taxis observed in the coordinate of the grid location in the specific time period.

~~15. The driver guidance system according to any of claims 12 to 14, the taxi prediction module further comprises a micro-movement model and an integrating neural network,~~
~~wherein the micro-movement model is trained on a second dataset of elapsed time of most recent vacant taxi for a plurality of road links of the unit grids and summary statistics of trips in the plurality of road links to correlate a probability of taxi demand in the road links to an elapsed time of most recent vacant taxi in the road links and output a micro-movement modifier reflecting the probability of taxi demand in the road links, wherein the road links are adjacent to form a region;~~

~~the integrating neural network is trained to combine and assign weightage on the demand count and the micro-movement modifier to generate a combined taxi demand prediction value,~~

~~wherein the taxi prediction module is further configured to generate, by the micro-movement model, a current micro-movement modifier, wherein the current micro-movement modifier reflects a current probability of taxi demand in the road links based on the current taxi dataset and to generate, by the integrating neural network, a current combined taxi demand prediction value based on the current demand count and the current micro-movement modifier; and~~

~~wherein the taxi coordination module is configured to provide personalised recommendations to the individual taxi driver based on the current demand count for the plurality of grid locations includes the taxi coordination module is configured to provide personalised recommendations to the individual driver based on the current combined taxi demand prediction value for the plurality of grid locations.~~

16.14. The driver guidance system according to any one of claims 11 to 13~~15~~, wherein the micro-movement model comprises at least two stacked Long Short-Term Memory (LSTM) networks.

17.15. The driver guidance system according to any of claims ~~15 to 16~~11 to 14 wherein the taxi prediction module further comprises a hybrid LSTM-TCN model, the hybrid LSTM-TCN model comprises at least two LSTM networks and a temporal convolutional network (TCN) trained on the first dataset and a third dataset of exogenous factors to output an exogenous taxi demand modifier, wherein the exogenous taxi demand modifier quantifies how exogenous factors affect the demand and supply of taxis, wherein the integrating neural network is further trained to combine and assign weightage on the exogenous taxi demand modifier, wherein the taxi prediction module is further configured to generate, by the hybrid LSTM-TCN model, a current exogenous taxi demand modifier based on the current taxi dataset and additional dataset comprising current

exogenous factors, and to generate, by the integrating neural network, the current combined taxi demand prediction value based on the current demand count, the current micro-movement modifier and the current exogenous taxi demand modifier.

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18-16. The driver guidance system according to claim 17-15 wherein the current taxi dataset and additional dataset are fed into the at least two LSTM networks and outputs from the LSTM networks serve as inputs to the TCN to output the exogenous taxi demand modifier.

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19-17. The driver guidance system according to any of claims 17-15 to 18-16 wherein the exogenous factors are selected from the following: meteorological conditions in the time period, temporal data in the time period and taxi-related data in the time period.

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20-18. The driver guidance system according to any of claims 12-11 to 19-17 further comprising a display unit to receive and display the personalised recommendations from the taxi coordination module.

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21-19. A display unit for a driver guidance system, the display unit comprising a receiver configured to receive personalised recommendations from the driver guidance system according to any of claims 12-11 to 19-17 and a graphical user interface to show the personalised recommendations.

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22-20. The display unit according to claim 19 further comprising a GPS module to determine a location of the display unit and a transmitter configured to transmit the location to the driver guidance system.

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23-21. A computer-implemented method for displaying a predicted taxi demand on a display unit, the method comprising receiving, by the display unit, a current demand count or a current combined taxi demand prediction value, wherein the current demand count or the current combined taxi demand prediction value is generated by a system implementing the method according to any

one of claims 1 to ~~8~~7; and displaying, by the display unit, the current demand count or the current combined taxi demand prediction value.

~~24~~22. The method according to claim ~~23~~21 further comprising transmitting, by the display unit, a current location of the display unit to the system, wherein the system further identifies at least one unit grid or road link with taxi demand proximal to the current location of the display unit based on the current demand count or the current combined taxi demand prediction value; and receiving data regarding the at least one unit grid or road link.

~~25~~23. The method according to claim ~~24~~22, receiving and displaying, by the display unit, a personalised recommendation for the display unit, wherein the personalised recommendation is generated by the system based on the current demand count or the current combined taxi demand prediction value and location of vacant taxis.

~~26~~24. A method of building a taxi demand prediction model, the method comprises providing a map of a city as a plurality of unit grids; ~~and~~ training a convolutional neural network using a first dataset of demand and supply of taxis at the plurality of unit grids over a plurality of time periods to output a demand count, wherein the first dataset is encoded as a plurality of three-dimensional images, and each three-dimensional image represents one unit grid over the plurality of time periods;

training at least two stacked Long Short-Term Memory (LSTM) networks using a second dataset of elapsed time of most recent vacant taxi for a plurality of road links of the unit grids and summary statistics of trips in the plurality of road links to correlate a probability of taxi demand in the road links to an elapsed time of most recent vacant taxi in the road links and to output a micro-movement modifier reflecting the probability of taxi demand in the road links, wherein the road links are adjacent to form a region; and training an integrating neural network to combine and assign weightage on the demand count and the micro-movement modifier to output a combined taxi demand prediction value.

~~27. The method according to claim 26 further comprises training at least two stacked Long Short-Term Memory (LSTM) networks using a second dataset of elapsed time of most recent vacant taxi for a plurality of road links of the unit grids and summary statistics of trips in the plurality of road links to correlate a probability of taxi demand in the road links to an elapsed time of most recent vacant taxi in the road links and to output a micro-movement modifier reflecting the probability of taxi demand in the road links, wherein the road links are adjacent to form a region; and~~

~~training an integrating neural network to combine and assign weightage on the demand count and the micro-movement modifier to output a combined taxi demand prediction value.~~

28-25. The method according to claim ~~27-24~~ further comprises training at least two LSTM networks and a temporal convolutional network (TCN) on the first dataset and a third dataset of exogenous factors to output an exogenous taxi demand modifier, wherein the exogenous taxi demand modifier quantifies how exogenous factors affect the demand and supply of taxis; and wherein the integrating neural network is further trained to combine and assign weightage on the exogenous taxi demand modifier.