Method and system for quasi real time prediction of at least one indicator of operation of a passenger transport network

The present invention relates to a method and a system for quasi-real-time prediction of at least one indicator of the operation of a passenger transport network, as well as a related transport network.

The invention is located in the field of passenger transport domain, in particular urban transport, in the context of an urban subway-type railway network, for the regulation of passenger flow in the network.

Such a passenger transport network is characterized by a set of stations and a set of lines, a line being defined by the set of stations served by a transport vehicle.

In addition, such a transport network includes a set of platforms for loading and/or unloading passengers, for example subway platforms.

Such a network has its own topology, some stations comprising several such platforms and being served by several lines of the network.

In modern transportation networks, for example in a subway network, each station is equipped with gantries, and each user is provided with a card allowing access to the network and having a related unique identifier, at least between their entry to the network and their exit. The gantries are equipped with sensors adapted to read the data on the card, which is, for example, equipped with a chip and data communication means. Thus, the transport network is equipped with a system for recording, in connection with an identifier, an entry time into the network and a related entry station, as well as an exit time and a related exit station.

In operation, the transport network with a given topology has operating parameters, comprising in particular the frequency of vehicle traffic on each line, which generally varies according to parameters such as time slots, the type of vehicle used, passenger load.

In the context of passenger transport networks of this type, it is critical to be aware of various indicators that characterize the operation of the network, especially the average waiting time for at least one platform of the network at various times (hours of the day, days of the week), or an average load in terms of the number of passengers waiting on a platform of the network during these same periods, or the average load of passenger vehicles.

The estimation of operation indicators for a transport network that is a complex technical system then allows the improvement of the network operation and the regulation of passenger flow, in particular to avoid safety problems. Indeed, overloads of passengers

waiting on a platform or in a transport vehicle train may lead to accidents. In addition, an overload of passengers in a transport vehicle causes excessive wear and tear on the equipment and may also lead to safety problems (for example, braking time).

To estimate such indicators of the operation of a passenger transport network, a traditional method of surveying is known, i.e., manual counting of passengers by persons assigned to this task on a one-off basis. This work is carried out on an ad hoc basis at a subset of stations, and provides sampled results that have limited reliability.

On the other hand, solutions based on graph theory are also known that involve modeling the transport network. These are complex methods, which require long computation times.

Methods are also known for estimating operation indicators by computation from passenger input/output data collected over long observation periods. This type of method makes it possible to obtain an estimate of the indicators observed on average but does not make it possible to predict the values of operation indicators with good precision.

There is a need to predict operation indicators more accurately and in near real time, over a given period of time from a present moment, in order to improve the possibility of regulating passenger flow in near real time. Indeed, this would make it possible to improve passenger safety. In addition, it would save resources and reduce wear and tear on rolling stock, in the event of network overload or underload.

For this purpose, the invention proposes a method for predicting at least one indicator of the operation of a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers into and/or out of a transport vehicle of the network, the network being equipped with a system for recording, related to an identifier, network input/output data, the method comprising a step a), prior to a current time instant, of collecting and storing input/output data of actual trips made during a past observation window preceding the current time instant.

This method comprises, for at least a first time interval included in the said observation window, steps of :

b) application of an estimation algorithm, from the said data collected during the said first time interval, of at least one indicator of the operation of the transport network estimated during the said first time interval,

c) implementing a plurality of automatic learning algorithms to calculate, for each automatic learning algorithm, from at least one subset of the data collected during the said

observation window and before the said first time interval, at least one indicator of the operation of a transport network predicted for the said first time interval,

(d) determining a weighted mixture of automatic learning algorithms, relevant at the current time instant, based on the said predicted indicator of the operation of a passenger transport network and the estimated indicator of the operation of a passenger transport network for the said first time interval,

e) for at least a second future time interval, having a start time later than or concomitant with the current time instant, implementing the said weighted mixture of the automatic learning algorithms to calculate at least one predicted performance indicator related to each second time interval.

Advantageously, the invention makes it possible to predict one or more operation indicators in the near future with respect to the current time instant, with improved accuracy. The taking into account of these indicators, by the operator of the transport network and/or by the passengers, makes it possible to regulate passenger flow and, in particular, to reduce overloads.

The method for predicting at least one indicator of the operation of a passenger transport network according to the invention may also present one or more of the following features, taken independently or in any technically conceivable combination.

The indicator of the operation of the transport network is selected from an average waiting time for each platform of the network, an average load, in number of passengers waiting on a platform of the network, an average load, in number of passengers, per transportation vehicle.

The steps b) to e) are repeated with a predetermined time frequency.

The plurality of automatic learning algorithms includes decision methods based on forests of decision trees and gradient regression methods.

The step c) of implementing a plurality of automatic learning algorithms comprises an implementation of the same automatic learning algorithm with several subsets of different input/output data collected during time observation sub-windows of different durations.

In addition, the method includes a prior step of learning parameters for each automatic learning algorithm, using data over at least one long learning period of more than one month.

According to another aspect, the invention relates to a method for regulating the flow of a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers in a

transport vehicle of the network, the network being equipped with a system for recording, in association with an identifier, the input/output data of the network, the network comprising, in addition, one of the electronic equipment and a supervision and computing center adapted to communicate with the said equipment. This flow control method comprises, at a current time instant :

-a prediction of at least one network operation indicator according to a method for predicting at least one passenger indicator of the operation of a passenger transport network as briefly described above;

-the use of the said at least one network operation indicator for the regulation of the passenger flow in the network.

According to one embodiment, the use step comprises steps of :

-calculation of at least one network operation parameter from the predicted operation indicator(s),

-transmission of the said at least one parameter or a related command to at least one electronic equipment of the network,

-modification of the operation of the said electronic equipment according to the said parameter.

According to a variant, the use step includes a publication of the said at least one operation indicator destined for user equipment suitable for wireless communication.

According to another aspect, the invention relates to a system for predicting at least one indicator of the operation of a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers in a transport vehicle of the network, the network being equipped with a system making it possible to record, in association with an identifier, the input/output data of the network, the system comprising a module for collecting and storing input/output data of actual journeys made during a past observation window preceding a current time instant.

This system comprises at least one calculation processor adapted to implement, for at least a first time interval included in the said observation window :

-a module for applying an estimation algorithm, from the said data collected during the said first time interval, of at least one indicator of the operation of the transport network estimated during the said first time interval,

- a module for implementing a plurality of automatic learning algorithms to calculate, for each automatic learning algorithm, from at least one subset of the data collected during the said observation window and prior to the said first time interval, at

least one indicator of the operation of the transport network predicted for the said first time interval,

- a module for determining a weighted mixture of the automatic learning algorithms, relevant at the current time instant, based on the said predicted indicator of the operation of a passenger transport network and the estimated indicator of the operation of a passenger transport network for the said first time interval,

- for at least a second future time interval, having a start time later than or concomitant with the current time instant, a module for implementing the said weighted mixture of relevant automatic learning algorithms determined to calculate at least one predicted performance indicator associated with each second time interval.

According to another aspect, the invention relates to an information recording device, on which are stored software instructions for the execution of a method for predicting at least one parameter characterizing the operation of a passenger transport network as briefly described above, when these instructions are executed by a programmable device.

According to another aspect, the invention relates to a computer program comprising software instructions which, when implemented by a programmable device, implement a method for predicting at least one parameter characterizing the operation of a passenger transport network as briefly described above.

Other features and advantages of the invention will emerge from the description, which is given below, as an indication and in no way limiting way, with reference to the appended figures, wherein :

- figure 1 is a schematic representation of a transport network according to one embodiment;

- figure 2 is a diagram illustrating the topology of a part of a transport network in which the invention is applicable;

- figure 3 is a flowchart of the main steps of a method for predicting at least one indicator of the operation of a transport network according to one embodiment;

- figure 4 is a flowchart of one embodiment of a flow control method in a passenger transport network according to an embodiment.

The invention will be described below in its application in an urban transport network R, for example a subway network.

As explained in the introduction, a transport network comprises a set of stations and a set of lines, a line being defined by the set of stations served by the vehicles, for example the trains in the case of a subway network. In addition, such a transport network includes a set of platforms for loading and/or unloading passengers, such as subway platforms. Such a network has its own topology, with some stations comprising several such platforms and being served by several lines of the network.

Each station has a related geographical location, for example indicated by coordinates in a geolocation reference frame such as GPS coordinates. Similarly, each platform has related geolocation coordinates.

Thus, it is possible to calculate the distances between stations and between platforms of the same station, and to calculate the average time required to cover these distances for a passenger.

Figure 1 schematically shows connected elements of a transport network R wherein the invention applies.

The transport network R includes a supervision and computing center 2, comprising programmable electronic devices 4 adapted to perform various calculations and to control various network equipment remotely, insofar as such equipment is equipped with control receivers, for example by a radio communication system. In the following, reference is made to a programmable electronic device 4, it being understood that reference 4 may also refer, alternatively, to a plurality of interconnected programmable electronic devices.

The computing and processing center 2 also includes electronic information storage devices 6, adapted to store a large volume of data.

In addition, the transport network R includes electronic equipment, for example, each station is equipped with a set 8 of electronic gantries 8A to 8D, and each user is provided with a card allowing access to the network and having a related unique identifier, at least between its entry into the network and its exit. The electronic gantries 8A to 8D are equipped with sensors adapted to read the data from the card, which is, for example, equipped with a chip and data communication means.

Thus, the transport network R is equipped with a system for recording, in connection with a card identifier, a time of entry into the network and a related entry station, as well as a time of exit and a related exit station.

The electronic gantries are adapted to transmit the recorded input/output data to the supervision and computing center 2. These input/output data are stored, for example, in the information storage device 6.

In one embodiment, the transport vehicle set 10 includes trains that are adapted to communicate with the supervision and computing center 2 and to receive control commands, for example via radio transceivers.

The network R includes equipment 12 facilitating mobility, such as escalators 12A, moving walkways 12B or elevators 12C. In one embodiment, at least part of the equipment 12 is adapted to receive commands from the supervision and computing center 2, for example for adjusting the operating speed or stopping the escalators and moving walkways.

The network R also includes electronic equipment 14 such as display panels, distributed in the stations or on the platforms, which can be used to display various information relating to the operation of the network.

The supervision and computing center 2 is adapted to receive additional information 16 from remote communication systems, such as planning or maintenance information useful for the operation of the various elements of the network R.

The programmable electronic device 4 of the supervision and computing center 2 is adapted to implement a method for predicting at least one network operation indicator according to the invention, and, if necessary, a modification of the network operation parameters depending on the predicted indicators in order to carry out a flow regulation in the network.

The network operation indicators are predicted for a future time interval subsequent to a current time instant.

An example of a network operation indicator related to a given time interval is the average waiting time for at least one network platform for the said time interval, or an average load in terms of the number of passengers waiting on a network platform during the time interval, or the average load of passenger vehicles on a given line during the time interval, or the average number of trains missed due to passenger overloading, on a given platform, during the considered time interval.

An operating parameter of the network is for example a display on the display panels 14, the frequency of trains on a given line, the load capacity of trains (for example, the number of trains), the operating speed of equipment 12, an operating mode of the electronic access gantries 8 (for example, blocked or slow operation or fast operation).

In one embodiment, the programmable electronic device 4 has a processor 20 able to implement :

-a module 22 collecting and storing input/output data of actual journeys during a past observation window, preceding the current time instant, the said past observation

window having a start instant, distant from the current time instant by a duration less than or equal to a first predetermined threshold,

- a module 24 for the application of an estimation algorithm, based on data collected during a first time interval, of at least one indicator of the operation of a passenger transport network estimated during this first time interval,

-a module 26 for implementing a plurality of automatic learning algorithms to calculate, for each automatic learning algorithm, from at least one subset of the data collected during the said observation window and prior to the said first time interval, of at least one indicator of the operation of a passenger transport network predicted for the first time interval,

-a module 28 for determining a weighted mixture of the automatic learning algorithms, relevant at the current time instant according to the indicators calculated by modules 24 and 26,

-a module 30 for the implementation of the weighted mixture of automatic learning algorithms determined to calculate, from at least one subset of the collected and stored data, at least one predicted operation indicator related to a second future time interval, having a start time later than the current time instant.

The programmable electronic device 4 also includes a module 32 for calculating operating parameters to be modified according to the predicted operation indicator(s) and for transmitting the parameters, or commands to modify these parameters, to the related equipment.

In one embodiment, these modules 22 to 32 are realized in the form of computer program instructions, executable by the programmable device. Alternatively, they are realized by programmable logic components, or in the form of dedicated integrated circuits (or ASICs).

Details of the implementation of the various modules implemented by a programmable electronic device capable of implementing the invention are given below.

In one embodiment, the supervision and computing center 2 allows the transmission of predicted operation indicators to user equipment 18A...18C, for example smartphones or any other equipment adapted to receive wireless communications, so as to warn network users/passengers of possible network congestion. This allows indirect flow control, for example, passengers receiving a congestion alert are then able to modify their journey (for example, route or schedule).

Figure 2 is a simplified schematic example of the topology of a part of the R transport network R comprising lines L_1, L_2 and L_3, and stations A, B, C and D, as well as other stations, shown by nodes and not referenced in Figure 2.

The platforms are not shown. Thus, the correspondence between lines involving a change of platform is not shown in Figure 2.

A journey between a departure station A and a destination station B is defined by a set of lines and connections that connect A and B.

In the example shown, several routes are possible to get from station A to station B.

It is planned that input data into the network R /output data from the network R of the transportation network, be systematically recorded, in the transport network, related to an ID, for example, a passenger pass card ID.

It should be noted that it is possible to collect input/output data related to an ID, but without knowing the passenger's actual journey in the network.

An entry data includes an entry station on the network, for example a station A, as well as a date and time of entry into the station, noted T_A, in relation to an identifier ID .

An output data includes an output station on the network, for example a station B, and a date and time of exit of the station B, noted T_B, in relation to an identifier ID.

The line L_1 connects stations A and B in six stops along a first route.

There is a first possibility of connection with line L_2, from station C. The journey from station A, on line L_1 and then on line L_2 from the connecting station C is a second journey between A and B and includes 3 stops.

There is also the possibility of connecting to line L_3 from station D, the third journey between A and B is a third route between A and B which in this case totals 9 stops. There are, a priori, 3 different possible routes between stations A and B. It is assumed that in the absence of incidents, the first and second routes have similar durations, and the third journey is twice as long.

Figure 3 is a synoptic of the main steps of a method for predicting the indicator(s) of the operation of a passenger transport network(s) according to one embodiment of the invention.

The method comprises a first step 40 of obtaining the data 38 either from the memories 6, either from a communication interface with a remote server or with an input/output interface of the programmable electronic device implementing the method.

The data comprises the input/output data of actual journeys taken during a past observation window.

The past observation window is determined with respect to a current time instant T_C of application of the method. For example, the observation window is a window of several tens of minutes to several hours before the current time T_C. In one embodiment, the observation window includes a full day. In a variant, the observation window starts at the beginning of the current day.

In a more general way, the considered past observation window is in the near past with respect to the current time instant. Preferably, the time instant of the beginning of the observation window precedes the current time instant by a duration less than or equal to a threshold, for example 15 minutes.

The data received 38 also comprises information on the transport network R, the lines, the stations, for example:

-GPS coordinates of the stations and/or platforms ;

-transfer times between platforms;

-train planning information;

The data 38 are collected and stored in step 40, which is followed by a step 42 of applying an estimation algorithm of at least one indicator of the operation of a passenger transport network estimated during a first time interval. The first time interval is within the past observation window and is defined by a starting time instant T_{11} and an ending time instant T_{12}.

Preferably, the first time interval is of the order of 15 minutes.

For example, the estimated operation indicator is the average waiting time for each platform of each station in the network during the first time slot.

Preferably, the computation algorithm used is the algorithm described in patent application FR1700181, which has a good computational efficiency.

This indicator of the operation of a passenger transport network estimation algorithm includes a preliminary step of calculation and recording, for each pair of network stations, of at least one route chosen between the two stations of the pair of stations, according to static data characterizing the transport network. It then includes for each input/output data obtained for the first time interval considered :

-an estimate of an effective journey time and a selection of a journey between the entry station and the exit station from among the journeys chosen related to the pair of stations formed by the entry station and the exit station;

-a calculation of at least one indicator characterizing the network operation, comprising the calculation of an average waiting time for each platform of the network

during the first time slot by implementing an iterative algorithm implementing, at each iteration :

- for each given input/output data, a calculation of a time difference between the estimated duration of the selected route and the actual journey duration;

-when the selected route includes at least one connection via a loading/unloading platform, an assignment of a fraction of the said time difference to each waiting time related to a connection platform.

The waiting time during the first time interval for each platform in the network is updated at each iteration.

At the end of step 42, a first estimated network operation indicator related to the first time interval is obtained, which is the average waiting time per platform, and optionally, other estimated operation indicators, for example, average load per platform or per vehicle are also calculated.

Step 42 is followed by a step 44 of implementing a plurality of automatic learning algorithms to calculate at least one predicted indicator of the operation of a transport network for the said first time interval. For each automatic learning algorithm, a predicted indicator is calculated from at least one subset of all the data collected during the said observation window and prior to the said first time interval, and from estimated operation indicator values, for example, according to the estimated algorithm previously described with reference to step 42, for time intervals within the observation window and prior to the first time interval.

The automatic learning algorithms are configured by learning parameters, which are obtained in a previous learning step 43 and stored. The learning step 43 typically uses very large volumes of data and requires a lot of calculations. It is performed with a low time frequency, for example at intervals of several months, on large volumes of data collected over a long learning period. For example, the learning period is between 1 and 36 months, preferably 14 months to take into account seasonality. The training data include, over the training period, values of transport network operation indicators per platform estimated by an estimation algorithm, by time interval bands, for example, 15 minutes, the number of inputs/outputs per station and per time interval band, calendar information (for example, weekends and holidays).

The learning parameters calculated for each of the automatic learning algorithms are stored.

For example, the automatic learning algorithms used comprise, on one hand, the prediction method based on random forest classifiers and on the other hand, the gradient boosting method.

Of course, other methods in the field of artificial intelligence (or "machine learning") known in the state of the art can be used.

In one particular embodiment of step 44, a first automatic learning algorithm, Meth1, using forests of decision trees is applied on N different data sets, N being a positive integer greater than or equal to 2 and thus N prediction results of operation indicators are obtained.

For example, the data sets differ by the time observation sub-window chosen, for example: 15 minutes, 30 minutes, 1 hour, 1 hour and 30 minutes, 2 hours, before the first time interval considered. Each data set is a subset of the data collected in step 40.

In this embodiment of step 44, a second automatic learning algorithm, Meth2, using "gradient boosting" is applied on M different data sets, where M is a positive integer greater than or equal to 2 and thus M prediction results of operation indicators are obtained.

In the same way as for the algorithm Meth1, for example, the data sets differ by the time observation sub-window chosen, for example: 15 minutes, 30 minutes, 1 hour, 1 hour and 30 minutes, 2 hours, before the first time interval considered.

Thus, at the end of step 44 we obtain several sets of predicted operation indicators for the first time interval considered, each set of predicted indicators being related to an automatic learning algorithm and a time observation sub-window.

In one embodiment, each set of predicted operation indicators includes one single predicted operation indicator, for example the average waiting time predicted for the first time interval per transport network platform.

Then in step 46, a step is implemented to determine a weighted mixture of automatic learning algorithms (Mixture Model), the most relevant at the current time instant, among the tested methods. Relevance here refers to the prediction efficiency, i.e., the weighted mixture of automatic learning algorithms that allows us to predict an operation indicator that is closest to the estimated operation indicator.

The weighted mixture of learning algorithms results in an aggregated automatic learning algorithm that is efficient at the current time, for the selected operation indicator.

For example, in this step, the predicted operation indicators calculated in step 44 are compared, one by one, with the estimated operation indicators calculated in step 42,

and the closest indicators are determined, and then a weighted mixture of learning algorithms is determined.

In an implementation variant, the step 46 implements a weight optimization loop defining the weighted mixture of automatic learning algorithms. The weighted mixture of automatic learning algorithms relevant to the current time determined in step 46 is then used in step 48 to predict a set of network operation indicators $\{IF_1,..., IF_K\}$ for a second time interval, which is a future time interval, having a start time later than or equal to the current time.

For example, the second time interval is defined by a start time T_{21} and an end time T_{22}, with T_{21} equal to the current time instant T_C and T_{22} equal to the current time instant T_C plus 15 minutes.

The set of predicted operation indicators $\{IF_1,..., IF_K\}$ can be limited, for example, to a predicted average waiting time IF_1 for the second future time interval, for each platform of the network.

In one embodiment, sets of predicted operation indicators for successive second time intervals are determined. For example, series of predicted operation indicators are determined in quarter-hourly increments for the 3 hours following the current time instant.

Advantageously, the method uses a weighted mixture of several automatic learning algorithms, trained on different subsets of data collected in the past, with the weighting related to this weighted mixture being learned in real time.

These predicted operation indicators are stored and transmitted to other modules adapted to use them to regulate the operation of the transmission network in step 50.

In a later step 52, in connection with a clock, unshown, new first and second time intervals are selected, relative to a future time instant. When the time has elapsed and the current time instant equals this future time instant, the steps 40 to 48 are iterated.

For example, the steps 40 to 48 are iterated with a fast time frequency, for example every quarter hour. Advantageously, the weighted mixture of the automatic learning algorithms relevant at the current time instant is adaptive and is performed dynamically, in quasi real time.

Thus, the predicted operation indicators $\{IF_1,..., IF_K\}$ are updated with this fast repetition time frequency, thus in quasi real time.

Figure 4 is a synoptic of the main steps of a flow control method in a passenger transport network, according to one embodiment, using a method for predicting network operation indicator(s) as described above.

The method comprises a first step 60 of predicting operation indicators over a future time interval with respect to the current time instant.

The method described above is implemented in step 60.

Then in step 62 the predicted operation indicators are published, for example via a dedicated application, to user equipment, for example smartphones, thus allowing users/passengers to be informed in quasi real time of the network operation to be predicted during the second time interval, i.e., in the near future, especially the average waiting time, platform and vehicle load. These predicted operation indicators are then either directly exploitable by users or exploitable by intermediate applications, for example to calculate a journey optimized in time or comfort between a station A and a station B of the network.

In step 64, implemented substantially in parallel with step 62, the predicted operation indicators are implemented in calculations to calculate the desired network operation parameters during the related time interval.

For example, the operating speed of the escalators 12A, the moving walkways 12B or the electronic gantries 8A to 8D is calculated, to avoid opening access to a given platform, for which an overload was predicted, to too many passengers. At the same time, the capacity of the trains for certain lines or the frequency of traffic is increased. In case of predicted underload, the capacity of the trains for certain lines or the frequency of traffic is decreased, and for example some moving walkways or escalators are stopped. Therefore, advantageously, the consumption of electrical energy is reduced. Thus, the flow of passengers in the network will be regulated.

The operation parameters calculated in step 64 are transmitted, possibly in the form of commands to be applied, to various electronic equipment in the network in step 66, for example to equipment 12 facilitating mobility in the network.

The calculated operation parameters are then applied by the electronic equipment related in step 68.

Advantageously, the invention makes it possible to improve the regulation of passenger flow, and consequently to optimize the use of resources (for example, electricity), to prevent wear and tear on the equipment and, in the event of expected overload, to improve passenger safety and comfort.

CLAIMS

1. A method for predicting at least one indicator of the operation of a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers in a transport vehicle of the network, the network being equipped with a system for recording, in association with an identifier, input/output data of the network, the method comprising a step, prior to a current time instant, of :

a) collection and storage (40) of input/output data of actual journeys made during a past observation window preceding the current time instant,

the method being characterized in that it comprises, for at least a first time interval included in the said observation window, steps of :

b) applying (42) an algorithm for estimating, from the said data collected during the said first time interval, at least one indicator of the operation of a passenger transport network, estimated during the said first time interval,

c) implementing (44) a plurality of automatic learning algorithms to calculate, for each automatic learning algorithm, from at least a subset of the data collected during the said observation window and prior to the said first time interval, at least one indicator of the operation of a passenger transport network, predicted for the said first time interval,

d) determining (46) a weighted mixture of the automatic learning algorithms, relevant at the current time instant, depending on the said predicted indicator of the operation of a passenger transport network and the estimated indicator of the operation of a passenger transport network for the said first time interval,

e) for at least one future second time interval, having a start time later than or concomitant with the current time instant, implementing (48) the said weighted mixture of the automatic learning algorithms to calculate at least one predicted operation indicator related to each second time interval.

2. The method according to the claim 1, wherein the said indicator of the operation of a passenger transport network is selected from an average waiting time for each network platform, an average load in number of passengers waiting on a network platform, an average load, in number of passengers, per transport vehicle.

3. The method according to one of the claims 1 or 2, wherein steps b) to e) are repeated with a predetermined time frequency.

4. The method according to any one of the claims 1 to 3, wherein the plurality of automatic learning algorithms comprises decision methods based on forests of decision trees and gradient regression methods.

5. The method according to the claim 4, wherein step c) of implementing a plurality of automatic learning algorithms comprises an implementation of the same automatic learning algorithm with several subsets of different input/output data collected during time observation sub-windows of different duration.

6. The method according to any one of the claims 1 to 5, further comprising a prior step of learning parameters for each automatic learning algorithm, using data over at least one, long learning period, of duration greater than one month.

7- A flow regulation method for a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers in a transport vehicle of the network, the network being equipped with a system making it possible to record, in association with an identifier, input/output data of the network, the network also comprising one of the electronic equipment and a supervision and computing center adapted to communicate with the said equipment, the flow regulation method being characterized in that it comprises, at a current time instant :

-prediction (60) of at least one network operation indicator according to a prediction method complying with any one of the claims 1 to 6 ;

-use (62, 64, 66, 68) of the said at least one network operation indicator for regulating the flow of passengers in the network.

8- The method according to the claim 7, wherein the use step comprises steps of:

-calculation (64) of at least one network operation parameter from the predicted operation indicator(s),

-transmission (66) of the said at least one parameter or a related command to at least one electronic equipment in the network,

-modification (68) of the operation of the said electronic equipment according to the said parameter.

9. The method according to the claim 7, wherein the use step comprises publishing (62) of the said at least one operation indicator to user equipment adapted to communicate wirelessly.

10. A computer program comprising software instructions which, when implemented by a programmable electronic device, implements a method for predicting at least one indicator of the operation of a passenger transport network according to the claims 1 to 6.

11. The system for predicting at least one indicator of the operation of a passenger transport network, the network comprising a set of stations, each station comprising at least one platform for loading and/or unloading passengers into and/or from a transport vehicle of the network, the network being equipped with a system for recording, in association with an identifier, input/output data of the network, the system comprising a module for collecting and storing input/output data of actual journeys made during a past observation window preceding a current time instant,

the system being characterized in that it comprises at least one calculation processor adapted to implement, for at least a first time interval included in the said observation window :

-a module (24) for applying an algorithm for estimating, from the said data collected during the said first time interval, at least one indicator of the operation of a passenger transport network estimated during the said first time interval,

- a module (26) for implementing a plurality of automatic learning algorithms to calculate, for each automatic learning algorithm, from at least one subset of the data collected during the said observation window and prior to the said first time interval, at least one indicator of the operation of a passenger transport network, predicted for the said first time interval,

- a module (28) for determining a weighted mixture of the self-learning algorithms, relevant at the current time instant, as a function of the said predicted indicator of the operation of a passenger transport networks and the estimated indicator of the operation of a passenger transport network for the said first time interval,

- for at least one future second time interval, having a start time later than or concomitant with the current time instant, a module (30) for implementing the said weighted mixture of relevant automatic learning algorithms determined to calculate at least one predicted operation indicator related to each second time interval.