

TRAFFIC ANALYSIS SYSTEM, TRAFFIC ANALYSIS PROGRAM, AND TRAFFIC ANALYSIS METHOD

TECHNICAL FIELD

The present invention relates to a traffic analysis system, a traffic analysis program, and a traffic analysis method. More specifically, the present invention relates to a traffic analysis system, a traffic analysis program, and a traffic analysis method, which are capable of estimating an arrival time and a departure time of a train or the like based on a user trip log.

BACKGROUND ART

Traffic service providers have made various approaches for improvement in convenience of public transportation and an efficient operation. For example, it is possible to perform congestion rate estimation or flow prediction by estimating movement routes of passengers using histories of traffic system IC tickets that have become common recently. In order to estimate movement routes of passengers accurately, timetable information is necessary. A traffic service provider has a planned timetable that is set in advance, but it is practically difficult to operate trains or buses as planned, a number of small-scale delays occur due to influence of an accident, a traffic jam, or the like, and a situation in which

an operation deviated from a plan has to be performed often occurs. In this regard, for example, when estimation of movement routes of passengers is performed, it is considered that more accurate analysis can be performed by using an actual timetable in which an actual arrival time and an actual departure time are collected instead of a planned operation timetable. However, there is a problem in that in order to collect an actual timetable mechanically, it is necessary to install a special device in a vehicle, a track, a road, or the like, and a large amount of expense and time are required.

Patent Document 1 discloses an operation management system with a train delay prediction display function equipped with an actual timetable generating unit.

Further, Patent Document 2 discloses a system of estimating an actual timetable based on the distribution of the number of alighted persons generated based on trip logs of passengers estimated to be passengers without transferring trains.

CITATION LIST

PATENT DOCUMENT

Patent Document 1: JP 2000-1168 A

Patent Document 2: PCT/JP2012/076750

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

The technique disclosed in Patent Document 1 is on the premise that it is possible to receive train location, station congestion information, garage information, weather information, and various information related to a current train operation in order to generate an actual timetable, but does not disclose a technique of generating an actual timetable without such information.

The technique disclosed in Patent Document 2 has a feature of estimating an actual timetable based on the distribution of the number of alighted persons, but uses only trip logs of passengers estimated to be passengers without transferring trains in order to remove trip logs of passenger who got off using another line. For this reason, there is a problem in that the number of trip logs used for estimation is smaller than the number of logs of passengers who got off using the corresponding line actually.

Further, since a peak of the distribution of the number of alighted persons generated by the above means has a defective or false peak when compared with an actual train arrival time, it is not easy to estimate an actual timetable based on the distribution of the number of alighted persons.

The present invention was made in light of the foregoing, and it is an object of the present invention to estimate an arrival time and a departure time of a train or the like based

on user trip logs with a higher degree of accuracy.

SOLUTIONS TO PROBLEMS

A representative example among means for solving the problems according to the present invention provides a traffic analysis system that estimates an actual timetable of a predetermined line using trip logs of passengers using transportation, and includes a route estimating unit that estimates a plurality of movement routes of the trip log from a departure station to an arrival station, a used line estimating unit that estimates the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value, and an actual timetable estimating unit that estimates the actual timetable based on an alighting time of the trip log estimated to have used the line by the used line estimating unit.

Further, provided is a program of estimating an actual timetable of a predetermined line using trip logs of passengers using transportation, and the program causes a computer to execute a step of estimating a plurality of movement routes of the trip log from a departure station to an arrival station, a step of estimating the trip log to be a log arriving at the arrival station using the line when the number

of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value, and a step of estimating the actual timetable based on an alighting time of the trip log estimated to have used the line in the step of estimating the trip log.

Further, provided is a traffic analysis method of estimating an actual timetable of a predetermined line using trip logs of passengers using transportation, and the traffic analysis method includes a step of estimating a plurality of movement routes of the trip log from a departure station to an arrival station, a step of estimating the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value, and a step of estimating the actual timetable based on an alighting time of the trip log estimated to have used the line in the step of estimating the trip log.

EFFECTS OF THE INVENTION

According to an embodiment of the present invention, it is possible to estimate an arrival time and a departure time of a train or the like based on user trip logs with a higher degree of accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system configuration diagram of traffic analysis system according to an embodiment of the present invention;

FIG. 2 is a diagram for describing a structure of traffic system IC card data according to an embodiment of the present invention;

FIG. 3 is a diagram for describing a structure of master data storing basic information of a station and a line according to an embodiment of the present invention;

FIG. 4 is a diagram for describing a structure of trip log data according to an embodiment of the present invention;

FIG. 5 is a diagram for describing a data structure of a planned timetable according to an embodiment of the present invention;

FIG. 6 is a flowchart illustrating a trip log generation processing procedure according to an embodiment of the present invention;

FIG. 7 is a flowchart illustrating a used line estimation processing procedure according to an embodiment of the present invention;

FIG. 8 is an explanatory diagram illustrating an example of used line estimation according to an embodiment of the present invention;

FIG. 9 is an explanatory diagram illustrating an example of a used line estimation result according to an embodiment of the present invention;

FIG. 10 is a flowchart illustrating an actual timetable estimation processing procedure according to an embodiment of the present invention;

FIG. 11 is an explanatory diagram illustrating a presentation example of a used line estimation result, a planned timetable, and an actual timetable estimation result according to an embodiment of the present invention;

FIG. 12 is a flowchart illustrating another example of an actual timetable estimation processing procedure according to an embodiment of the present invention;

FIG. 13 is an explanatory diagram illustrating an example of a representative alighting time estimation process according to an embodiment of the present invention;

FIG. 14 is an explanatory diagram illustrating an example of an average inter-station required time calculation process according to an embodiment of the present invention;

FIG. 15 is an explanatory diagram illustrating another example of an actual timetable estimation process according to an embodiment of the present invention;

FIG. 16 is a flowchart illustrating an example of a boarding train estimation process according to an embodiment of the present invention;

FIG. 17 is an explanatory diagram illustrating an example of a seating preference route according to an embodiment of the present invention;

FIG. 18 is an explanatory diagram illustrating the details of a boarding train estimation process according to an embodiment of the present invention; and

FIG. 19 is an explanatory diagram illustrating an example of a boarding train estimation result according to an embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

Hereinafter, an embodiment of the present invention will be described with reference to the appended drawings. FIG. 1 is a system configuration diagram of a traffic analysis system according to an embodiment of the present invention.

In recent years, many users 101 using transportation pass through a ticket gate for transportation use or a reading terminal 102 installed in a vehicle using a non-contact IC card or a mobile terminal 103 having the same function. Data acquired by the ticket gate or the in-vehicle terminal is transmitted to a server group 105 managed by each traffic service provider via a network 104.

A traffic analysis system 107 includes a data server 111, a calculation server 112, and an information delivery server 113, and accumulates movement data obtained by collecting use

data of the non-contact IC card or the mobile terminal 103 having the same function and performs an analysis process. Further, a function or a configuration of a non-contact IC card, a ticket gate, or the like and an information processing technique which does not relate directly to a description of the present invention will be omitted.

When the user 101 with the non-contact IC card 103 passes through the ticket gate 102, a user ID identifying the IC card 103 and positional information including a passage date and time and the like are accumulated in the ticket gate 102 and accumulated in the server 105 managed by the traffic service provider as original data. The necessary item of data is transmitted to the data server 111 via the network 104 at the same time as the accumulating or an appropriate timing such as every other hour or every other day. The traffic analysis system 107 configured with the server group of the data server 111, the calculation server 112, and the information delivery server 113 is connected to the network 104 and can communicate with the user 115 and the traffic service provider 117. Thus, for example, the traffic service provider 117 can cause the traffic analysis system 107 to collaborate with another system such as an operation management system or an IC card data management system. In the present embodiment, the server group of the data server 111, the calculation server 112, the information delivery server 113 is described, but a

configuration in which the function of the server group can be executed through one or more servers can be provided.

The data server 111 receives data of the user read by an IC card reader terminal such as the ticket gate via the network 104, and records the received data in a data storage unit 121 in the server. For example, data to be collected and stored includes traffic system IC card data 122 and basic master data 123 related to a station/bus stop or a line. For example, trip log data 124 obtained by primarily processing the traffic system IC card data 122 and the like, a planned timetable 125, an actual timetable 126 generated by the traffic analysis system 107, and route choice preference pattern 127 used for route estimation of a passenger are further stored. When the basic master data 123 related to a station or a line is changed or updated, the basic master data 123 is input from the outside of the system, updated and recorded.

The calculation server 112 performs a process of generating movement data based on the data accumulated in the data server 111, a process of estimating a movement route of a passenger, a process of estimating an actual timetable, and the like. The calculation server 112 mainly includes a network interface (I/F) (A) 130, a central processing unit (CPU) 131, a memory 132, and a storage unit 133. The network interface is an interface for a connection with a network. The storage unit

133 includes a program group of a trip log generation program 134, a route estimation program 135, a used line estimation program 136, an actual timetable estimation program 137, and a boarding train estimation program 138 and a data storage unit 139 that stores, for example, a statistical value or an index value obtained as a result of a calculation process. Examples of the storage unit include a hard disk drive, a CD-ROM drive, and a flash memory. Further, various kinds of programs and various kinds of data may be divided and recorded in a plurality of recording devices.

When each program group is executed, various kinds of functions are implemented by reading data serving as an analysis target from the data server 111, temporarily storing the read data in the memory 132, and reading and executing the programs 134, 135, 136, 137, and 138 through the CPU 131. For example, the programs may be executed at a timing requested by an operator 119, the user 115, or the traffic service provider 117 or may be executed when new data is added to the data server 111, and a process may be automatically performed as a batch process at a time that is decided every day.

The information delivery server 113 includes a network interface I/F (B) 145, a CPU 146, a memory 147, and a recording device 148. The network interface is an interface for a connection with a network. The recording device records various kinds of programs and various kinds of data, and is,

for example, a hard disk drive, a CD-ROM drive, a flash memory, or the like. Further, various kinds of programs and various kinds of data may be divided and recorded in a plurality of recording devices.

The information delivery server 113 is used when the traffic service provider 117 or the user 115 refers to an actual timetable or an analysis result of people flow analysis, delay situation analysis, and the like using a generated actual timetable from the mobile information terminal 116 or a stationary information terminal 118 via a network 114. The recording device 148 includes a display screen generation program 141 and an information delivery program 142. The CPU 146 executes various kinds of functions by reading various kinds of programs recorded in the recording device 148 onto a memory and executing the read programs.

FIG. 2 is a diagram illustrating a structure of the traffic system IC card data 122 serving as representative data stored in the data server 111. First, the traffic system IC card data 122 includes information such as a log ID 201, a user ID 202 serving as a target, a station/bus stop ID 203 associated from information indicating a data reading terminal through which the user passed, a use time 204 at which the user passed through the reading terminal, a use type 205 indicating an entrance or an exit, or the like. Here, for example, the use type refers to information indicating an

"entrance" or an "exit" in the case of a ticket gate or an entrance/exit gate and a processing type such as "purchase" in the case of a terminal for product sales. The traffic system IC card data 122 may be transmitted when data is newly generated or may be collectively transmitted in the middle of the night in which the use is small. Preferably, the data server 111 side performs a storage process according to a transmission timing.

FIG. 3 is a diagram illustrating a type of master data 123 stored in the data server 111 and each data structure. First, a position master 300 serving as basic data related to a place at which a transportation means can be used such as a station, a bus stop, or a road includes information such as a station/bus stop ID 301, a station/bus stop name 302, a possession company 303, a location 304 such as an address, information 305 of a latitude and a longitude, and the like. When a configuration of a station, a bus stop, a line, or a road is changed, data is added or corrected as necessary. A line master 310 serving as basic data related to a line includes information such as a line ID 311 identifying a line, a line name 312, an operating company 313, a line type 314 indicating a train line or a bus line, and the like. A station/bus stop-line-related master 320 serving as basic data for associating a station and a line includes information such as a line ID 321 identifying a line, a station/bus stop ID 322

included in a corresponding line, a sequence number 323 used to manage a sequence of a station/bus stop, a type 324 identifying stopping or passing, a required time 325 from a starting point, and the like. For example, when a station, a bus stop, a line, or a road is changed, the master data 123 is input, updated, or recorded from the outside of the system illustrated in FIG. 1 each time when the change is made.

FIG. 4 is a diagram illustrating a data structure for storing the trip log data 124 stored in the data server 111. The trip log data 124 includes information such as a log ID 401 identifying a log, a user ID 402 serving as a target, a boarding date and time 403 indicating a time at which the use of the transportation means starts at a departure point, an alighting date and time 404 indicating a time at which the use of the transportation means ends at an arrival point, a paid amount 405 indicating a fee expended for movement, a boarding station/bus stop ID1 406, an alighting station/bus stop ID1 407, a boarding station/bus stop ID2 408, an alighting station/bus stop ID2 409, and the like. The trip log data 124 is primarily processed data generated using the traffic system IC card data 122 and the like.

FIG. 5 is a diagram illustrating a data structure for storing the planned timetable 125 stored in the data server 111. Planned timetable data 125 includes information such as a timetable ID 501 identifying a timetable, a line ID 502, a

stop station or bus stop 503, an arrival time 504, and a departure time 505.

FIG. 6 is a diagram for describing a processing procedure of the trip log generation program 134 of generating the trip log data 124 based on the traffic system IC card data 122 and storing the generated trip log data 124 in the data server 111. Here, a process of storing data in the data server 111 is described as being performed by a batch process at a decided time once a day. First, all data is sorted in the order of user IDs and the chronological order with reference to the user ID 202 and the use time 204 included in the traffic system IC card data 122 which is newly connected (processing step 601). Then, the following same process is performed on the data sorted in processing step 601 repeatedly by the number of user IDs (processing step 602). First, a list type variable corresponding to a boarding station/bus stop ID, a boarding date and time, an alighting station/bus stop ID, and an alighting date and time is initialized (processing step 603). Then, the following same process is repeatedly performed on the data arranged in the chronological order (processing step 604). First, a case classification is performed according to a value of the use type 205 (processing step 605), and each process is performed. When the value of the use type 205 indicates an entrance, first, it is checked whether there is an immediately previous exit log among logs of the same user

and the same date (processing step 606). When there is an exit log, it is determined whether or not a difference between an alighting date and time and a boarding date and time of a current log is within a predetermined threshold value (processing step 607). The threshold value is a value used to determine transfer of a plurality of transportations and preferably set in a range of several minutes to several tens of minutes, for example. When the difference between the alighting date and time of the immediately previous exit log and the boarding date and time of the current log is within the threshold value, a series of movements are regarded to be continuously performed, and a value is added to the list of the boarding station/bus stop ID and the boarding date and time (processing step 608). When the difference between the alighting date and time of the immediately previous exit log and the boarding date and time of the current log exceeds the threshold value, it is considered that there is a sufficient free time after an immediately previous movement, and thus immediately previous movement information may be determined to be delimited herein. Thus, a value of the variable is stored in the trip log data 124 (processing step 609), and the variable is initialized again (processing step 610). When there is no immediately previous exit log, a value is added to the list of the boarding station/bus stop ID and the boarding date and time (processing step 611). When the value of the use

type 205 indicates an exit, a value is added to the variable of the alighting station/bus stop ID and the alighting date and time (processing step 612). If the value is set to the variable when the repetition process has ended on the user ID, the value of the variable is stored in the trip log data (processing step 613). Here, the log ID 201 is held as a serial number. Here, the threshold value t used to determine whether or not a movement is a series of movements is assumed to be set as a standard transfer time in advance. It is possible to adjust a permissible range of the transfer time based on the threshold value t . The threshold value t related to the standard transfer time is a positive value, and may be a common value in all traffic networks or may be set to a different value for each area.

FIG. 7 is a diagram for describing a processing procedure of the used line estimation program 136 of estimating a used line of each trip log using the trip log data 124. The process is repeated by the number of trip logs (processing step 701). First, routes that depart from a boarding station and arrive at an alighting station are searched based on a plurality of search criteria (processing steps 702 and 703). In the present embodiment, the description will proceed with an example in which there are three types of criteria, that is, a time preference criterion, a transfer number preference criterion, and a fee preference criterion as an route selection criterion.

The usable route selection criteria are not limited to three. Then, it is determined whether or not the number of routes having the same movement direction among all the searched routes is a predetermined threshold value or more (processing step 704).

Here, the details of processing step 704 will be described with reference to FIG. 8. FIG. 8 illustrates a result of searching a movement route from a boarding station 801 to an alighting station 802 according to the time preference criterion, the transfer number preference criterion, and the fee preference criterion. A time preference route 803 moves to a station C 808 via a line 1 809 and arrives at a transfer alighting station 802 via a line 2 811. The transfer number preference route 804 and the fee preference route 805 are the same, and arrives at the alighting station 802 using a line 3 810. When there is a relevant route, an actual timetable is considered to be estimated for the line 3.

In this case, in the technique disclosed in Patent Document 2, it was difficult to use the trip log from the boarding station to the alighting station in FIG. 8 for estimation of an actual timetable of the line 3. It is because the route from the boarding station includes routes passing through the stations C and B using the lines 1 and 2, and thus it was difficult to specify that it was necessarily a log using the line 3 uniquely.

On the other hand, in the traffic analysis system according to the present embodiment, in processing step 704, in order to determine whether or not the movement directions of the searched routes are identical, a station (a station A in estimation of the line 3) before the alighting station of each route is checked. A line used to arrive at the alighting station is estimated by checking a station that is high in a probability to be a station prior to the alighting station. As a specific technique, a predetermined threshold value is set in advance, and it is determined whether or not a probability that an appropriate route (a route having a reasonable benefit compared to other lines such as the number of transfers, a fee, a time, or the like) will pass through the station A exceeds the threshold value. In the example of FIG. 8, in two of (the transfer number preference route 804 and the fee preference route 805) the three routes, the station A 806 is the station prior to the alighting station, and the line 3 810 is used to arrive at the alighting station 802, and in one (the time preference route 803) of the three routes, the station B is the station before the alighting station, and the line 2 811 is used to arrive at the alighting station 802. At this time, for example, when the predetermined threshold value is 0.5, the two (0.67) of the three routes exceed the threshold value and thus are high in a probability that movement will be performed while passing at least through the station A. In

other words, a probability that the line 3 810 will be used is high. In this regard, the corresponding log is estimated to be a log of the user who arrived at the alighting station 802 using the line 3 810. At this time, an alighting time of the corresponding log is recorded as an arrival time candidate of the alighting station of the corresponding line (processing step 705).

As described above, the traffic analysis system according to the present embodiment that estimates an actual timetable of a predetermined line using trip logs of passengers using transportation includes a route estimating unit 135 that estimates a plurality of movement routes of the trip log from a departure station to an arrival station, a used line estimating unit 136 that estimates the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value, and an actual timetable estimating unit 137 that estimates the actual timetable based on an alighting time of the trip log estimated to have used the line by the used line estimating unit.

Further, a traffic analysis method of estimating an actual timetable of a predetermined line using trip logs of passengers using transportation (a program of executing the traffic analysis method, and a storage medium storing the

program) includes a step (702) of estimating a plurality of movement routes of the trip log from a departure station to an arrival station, a step (704) of estimating the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value, and a step (1001 to 1005) of estimating the actual timetable based on an alighting time of the trip log estimated to have used the line in the step of estimating the trip log.

Due to the relevant features, it is possible to increase the number of logs used for estimation, compared to estimation using a log in which only routes using the corresponding line are present as in Patent Document 2, and thus it is possible to increase the accuracy of estimation.

In this regard, when a gate exit time is actually recorded as an alighting time of a trip log, there is an error with a train arrival time. In this regard, in processing step 705, an alighting time of a trip log may be corrected based on predetermined information. For example, an average movement time from the line arrival platform of the alighting station to the ticket gate may be used as the predetermined information.

FIG. 9 is a diagram illustrating an example of a result of a used line estimation process of the used line estimation

program 136. The number of trip logs estimated to have alighted from the corresponding station using the corresponding line at each time is recorded for each station of each line. Generally, a passenger is expected to exit from the ticket gate without staying after alighting from a train, and thus a number of trip logs are considered to be concentrated around a train arrival time.

FIG. 10 is a diagram for describing an example of a processing procedure of the actual timetable estimation program 137. An actual timetable estimation procedure is performed for each line (processing step 1001). First, the planned timetable of the corresponding line is slightly corrected (processing step 1002). A method of shifting the departure and arrival times backward and forward by several seconds to several minutes for the entire timetable, for each train, or for each station is considered as a correction method. Then, a degree of coincidence between the alighting time of the corrected planned timetable and the alighting time of the trip log using the corresponding line estimated by the used line estimation program 136 is calculated (processing step 1003). The number of trip logs in which the train arrival time of the corrected planned timetable is identical to the alighting time can be used as a degree of coincidence. A predetermined threshold value including an error may be set to the alighting time of the trip log, and when a difference

between the train arrival time of the corrected planned timetable and the alighting time is within the threshold value, the train arrival time of the corrected planned timetable may be determined to be identical to the alighting time. When a degree of coincidence is highest among degrees of coincidence calculated until now, the corresponding corrected planned timetable is recorded as an actual timetable (processing step 1005). A corrected planned timetable that is highest in a degree of coincidence is finally recorded in the data server 111 as the actual timetable 126. Generally, since it is rare that the planned timetable is significantly different from the actual timetable, it is possible to estimate an actual timetable with a higher degree of accuracy according to the relevant method.

FIG. 11 illustrates an example of an estimation result presentation screen of the used line estimation program 136 and the actual timetable estimation program 137 according to the display screen generation program 141. The operator 119 can select a line from a pulldown menu 1102 in a screen 1101. A used line estimation result 1104, a planned timetable 1105, and an actual timetable estimation result 1106 of the selected line are displayed on a display screen 1103. When there is an error in the actual timetable estimation result, the operator 119 can correct the actual timetable 1106 using a cursor 1107. When the actual timetable is corrected, a GUI in which the

operator can intuitively correct the actual timetable as in FIG. 11 is useful because the operator can easily understand whether the front side has to be corrected on a time axis or the opposite side has to be corrected, and there is information of improving the accuracy of correction.

FIG. 12 is a diagram for describing another example of a processing procedure of the actual timetable estimation program 137. The actual timetable estimation procedure is performed for each line (processing step 1201). Then, a process of each station in a corresponding line is performed (processing step 1202). A representative alighting time is decided based on alighting times of use logs of respective stations (processing step 1203). The representative alighting time refers to an alighting time representing a subset when trip logs are divided such that logs that are close in an alighting time are included in the same subset.

Here, a method of deciding the representative alighting time will be described in detail with reference to FIG. 13. A clustering technique is preferable as the method of deciding the representative alighting time. When the number of operated lines per day is known, a clustering technique such as K-means clustering method or a Gaussian mixture model can be used, and when the number of operated lines per day is unknown, a clustering technique such as a Dirichlet Process mixture model can be used. Since a known technique can be used as the

clustering technique, a detailed description is omitted. By applying the clustering technique, it is possible to divide an alighting time of a use log of a corresponding line into a plurality of clusters (the middle from the top in FIG. 13). Then, it is possible to obtain a representative alighting time by deciding a representative value of the divided clusters (the bottom in FIG. 13). As a representative value decision technique, it is desirable to use an average value, a median value, or a mode value of the alighting times in the cluster. By obtaining a representative alighting time from an alighting time of a use log of a corresponding line, it is possible to remove an error of a used line estimation result included in a use log.

Then, the actual timetable estimation program 137 performs a process between stations (processing step 1204). A correlation of a representative alighting time between a certain station and a next station is obtained, a time difference τ that is highest in the correlation is obtained, and the time difference τ is used as an average required time between the corresponding station and the next station (processing step 1205). A correlation when the time difference is τ is calculated by Formula 1.

[Math. 1]

$$C(\tau) = \sum_{t=0}^T X(t)Y(t+\tau)$$

Here, $X(t)$ is an array in which the representative

alighting time of the corresponding station is stored, and $X(t)$ is 1 when a time t is the representative alighting time. $Y(t)$ is an array in which a representative alighting time of the next station of the corresponding station is stored. When the average required time of the corresponding station and the next station is τ , if the time t is the representative alighting time of the corresponding station, a time $t+\tau$ is expected to be the representative alighting time of the next station. Thus, the correlation is highest when τ is the average required time of the corresponding station and the next station. FIG. 14 illustrates an example of a correlation calculation result.

Next, the actual timetable estimation program 137 searches for a representative alighting time in which the time difference is close to the average required time between the stations calculated in processing step 1205 and thus generates the actual timetable (processing step 1206). Since there is a possibility that the representative alighting time has a deficit, the actual timetable can be corrected by interpolating the deficit (processing step 1207). FIG. 15 illustrates a conceptual processing diagram of processing step 1206 and processing step 1207. An actual timetable is generated by connecting representative alighting times 1502 of next stations so that a time difference 1503 with a representative alighting time 1501 of a certain station

becomes an average required time between stations calculated in processing step 1205. An interpolation is performed on a deficit portion of the representative alighting time (1504).

As described above, the actual timetable estimation program 137 can estimate the actual timetable using the planned timetable when the planned timetable can be used and estimate the actual timetable by calculating the representative alighting time and the average required time between stations when it is difficult to use the planned timetable.

FIG. 16 is a flowchart illustrating an example of a processing procedure of the boarding train estimation program 138. The process is repeated by the number of trip logs (processing step 1601). First, a route search is performed on each route preference pattern recorded in the route choice preference pattern 127 stored in the data server 111 (processing steps 1602 and 1603). The route choice preference pattern 127 stores the passenger route selection criterion considered when the route search is performed. As the route selection criterion, a "time preference criterion" of selecting a route arriving at an alighting station earliest, a "transfer preference criterion" of selecting a route in which the number of transfers is smallest, a "fee preference criterion" of selecting a route in which a fee is cheapest, a "congestion avoidance criterion" of selecting a route in which

a train is most empty, a "seating preference criterion" in which a movement is performed in an opposite direction to an alighting station from a boarding station in order to take a seat in a congested train, and it is preferential to return up to a starting station of a corresponding line and secure a seat, or the like is considered. The route search according to the time preference criterion, the transfer preference criterion, the fee preference criterion, or the congestion avoidance criterion can be implemented by solving a shortest path problem by an algorithm such as a Dijkstra's algorithm by expressing a railroad network by a graph structure such as a station is represented as a node, and a track connecting stations is represented as an edge and using a required time, the number of transfers, a fee, or a degree of congestion as a weighting between stations. Since a known technique can be used as a solution to the shortest path problem, a detailed description is omitted.

Here, the route search according to the seating preference criterion will be described in detail with reference to FIG. 17. When there is congestion in a route 1703 from a boarding station 1701 to an alighting station 1702, it returns to a starting station 1704 in an opposite direction once, and a route 1705 toward the alighting station 1702 is selected, and thus seating at the starting station 1704 is more preferential than an increase in a movement time. The

seating preference route 1705 can be searched by adding a round-trip route between the boarding station 1701 and the starting station 1704 in the searched general route 1703. Since it is appropriate to select the seating preference route 1705 when the number of stations between the boarding station 1701 and the starting station 1704 is small or when the number of stations from the boarding station 1701 to the alighting station 1704 is large, the seating preference route 1705 may be searched only when the number of stations between the boarding station 1701 and the starting station 1704 is a predetermined threshold value or less or only when the number of stations from the boarding station 1701 to the alighting station 1704 is the predetermined threshold value or more. Depending on the traffic service provider, there are cases in which the return transfer is prohibited. In this case, the present invention is intended to apply the seating preference criterion to route search candidates instead of recommending relevant prohibited activities and enable the traffic service provider to understand the true state of the return transfer.

Then, the boarding train estimation program 138 performs boarding train estimation for each of the searched routes (processing steps 1604 and 1605). The details of the boarding train estimation will be described with reference to FIG. 18. First, a train having a most recent departure time 1802 after a boarding time 1801 is specified using the boarding time 1801

of a trip log and the actual timetable 126 estimated by the actual timetable estimation program 137. When the boarding time 1801 of the trip log is actually a ticket gate entrance time, a time to which a predetermined estimated movement time is added can be used. Actually, since there is a variation in a movement time of a passenger from a ticket gate to a platform, the passenger is not necessarily able to get on the train having the departure time 1802 closest to the boarding time 1801. In this regard, a train having a next departure time 1803 is added as a boarding train candidate as well. Similarly in a boarding station 1804, trains of a plurality of departure times are added as the boarding train candidate. The number of trains added as the boarding train candidate may be decided according to a threshold value or the like. Then, when an alighting time 1805 of the trip log is an exit time, an exit time 1807 obtained by adding a predetermined estimated movement time to an arrival time 1806 of the boarding train candidate is compared with an exit time 1805 of the trip log, and a train having the most recent exit time is assumed to be the boarding train. Finally, a train in which the exit time 1805 of the trip log is closest to the exit time 1807 of the estimated boarding train candidate in the searched route is output as the boarding train. In the present embodiment, the train in which the exit time 1805 of the trip log is closest to the exit time 1807 of the estimated boarding train

candidate is output as the boarding train, but the boarding train estimation method is not limited to this example. For example, the boarding train may be decided based on a predetermined priority from among a plurality of estimated boarding train candidates in which the difference between the exit time 1805 of the trip log and the exit time 1807 of the estimated boarding train candidate is within a predetermined threshold value. In the present embodiment, the route search (processing step 1603) and the boarding train estimation (processing step 1605) using the actual timetable 126 are separately performed, but the search in which the actual timetable 126 is considered may be performed at the time of the route search (processing step 1603).

FIG. 19 illustrates an example of an estimation result presentation screen of the boarding train estimation program 138 by the display screen generation program 141. When the operator 119 selects an arbitrary station 1902 on a route map in a screen 1901, a route selection rate of passengers in a corresponding station is displayed as a cumulative area graph 1904 in a screen 1903. A horizontal axis of the cumulative area graph 1904 indicates a time, and a vertical axis indicates the number of persons representing the details of the route selection criterion estimated from the trip logs of the passengers of the corresponding station at a corresponding time. Since it is possible to understand the ratio of the

route selection criterion in a desired station and a change form thereof easily, a GUI illustrated in FIG. 19 is useful. The method of presenting the ratio of the route selection criterion is not limited to the cumulative area graph, and a circular graph or the like may be used. Further, the route selection rate of the alighted passengers may be presented instead of the route selection rate of the passengers, and the operator 119 may select a line as well as a station.

REFERENCE SIGNS LIST

- 101 User
- 102 Reading terminal
- 103 Mobile terminal
- 104 Network
- 105 Server group
- 107 Traffic analysis system
- 111 Data server
- 112 Calculation server
- 113 Information delivery server
- 114 Network
- 115, 117 Traffic service provider
- 121 Data storage unit
- 122 Traffic system IC card data
- 123 Master data
- 124 Trip log data

125	Planned timetable
126	Actual timetable
127	Route choice preference pattern
130	I/F
131	CPU
132	Memory
133	Storage unit
134	Trip log generation program
135	Route estimation program
136	Used line estimation program
137	Actual timetable estimation program
138	Boarding train estimation program
139	Data storage unit
141	Display screen generation program
142	Information delivery program
145	I/F
146	CPU
147	Memory
201	Log ID
202	User ID
203	Station/bus stop ID
204	Use time
205	Use type
300	Station/bus stop master
301	Station/bus stop ID

302	Station/bus stop name
303	Possession company
304	Location
305	Latitude and longitude
310	Line master
311	Line ID
312	Line name
313	Operating company
314	Line type
320	Station/bus stop/line-related master
321	Line ID
322	Station/bus stop ID
323	Sequence
324	Type
325	Required time from starting point
401	Log ID
402	User ID
403	Boarding date and time
404	Alighting date and time
405	Paid amount
406	Boarding station/bus stop ID1
407	Alighting station/bus stop ID1
408	Boarding station/bus stop ID2
409	Alighting station/bus stop ID2
501	Timetable ID

502 Line ID

503 Stop station

504 Arrival time

505 Departure time

601 to 1005 Step

1101 Screen

1102 Pulldown menu

1103 Display screen

1104 Used line estimation result

1105 Planned timetable

1106 Actual timetable estimation result

1107 Cursor

1201 to 1207 Step

1501 Representative alighting time

1502 Representative alighting time of next station

1503 Time difference

1504 Interpolation

1601 to 1605 Step

1701 Boarding station

1702 Alighting station

1703 Route

1704 Starting station

1705 Seating preference route

1801 Boarding time

1802 Departure time

1803 Next departure time

1804 Boarding station

1805 Exit time

1806 Arrival time

1807 Exit time

1901 Screen

1902 Station

1903 Screen

1904 Graph

CLAIMS

1. A traffic analysis system that estimates an actual timetable of a predetermined line using trip logs of passengers using transportation, comprising:

a route estimating unit that estimates a plurality of movement routes of the trip log from a departure station to an arrival station;

a used line estimating unit that estimates the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value; and

an actual timetable estimating unit that estimates the actual timetable of the line based on an alighting time of the trip log estimated to have used the line by the used line estimating unit.

2. The traffic analysis system according to claim 1,

wherein a planned timetable is corrected so that a degree of coincidence between the alighting time of the trip log of each line and the alighting time of the planned timetable becomes maximum, and the corrected planned timetable is used as the actual timetable.

3. The traffic analysis system according to claim 1,
wherein the trip logs of each line are divided such that the trip logs having close alighting times are included in the same subset, a calculation of obtaining a representative alighting time representing the subset is performed, and the representative alighting time is used as an estimation result of a train arrival time of the line.

4. The traffic analysis system according to claim 1,
wherein a calculation of obtaining a correlation between neighboring stations of the trip log of each line is performed, and a time difference having the highest correlation is used as an average required time between the neighboring stations.

5. The traffic analysis system according to claim 1, further comprising,
a display unit that displays an alighting time of the trip log of each line, a planned timetable, or the actual timetable on the same screen.

6. The traffic analysis system according to claim 5, further comprising,
a correcting unit that corrects the actual timetable on the screen.

7. The traffic analysis system according to claim 1, further comprising,

a boarding train estimating unit that estimates a train which the passenger corresponding to the trip log gets on using the actual timetable when a plurality of routes from the departure station to the arrival station are searched according to at least one of a time preference criterion, a transfer preference criterion, a fee preference criterion, a congestion avoidance criterion, and a seating preference criterion for each of the trip logs.

8. The traffic analysis system according to claim 7, further comprising,

a display unit that displays a ratio of a route selection criterion estimated as a result of boarding train estimation.

9. A program of estimating an actual timetable of a predetermined line using trip logs of passengers using transportation, the program causing a computer to execute:

a step of estimating a plurality of movement routes of the trip log from a departure station to an arrival station;

a step of estimating the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or

equal to a predetermined threshold value; and

a step of estimating the actual timetable based on an alighting time of the trip log estimated to have used the line in the step of estimating the trip log.

10. A traffic analysis method of estimating an actual timetable of a predetermined line using trip logs of passengers using transportation, comprising:

a step of estimating a plurality of movement routes of the trip log from a departure station to an arrival station;

a step of estimating the trip log to be a log arriving at the arrival station using the line when the number of routes passing through a station prior to the arrival station in the line among the plurality of movement routes is more than or equal to a predetermined threshold value; and

a step of estimating the actual timetable based on an alighting time of the trip log estimated to have used the line in the step of estimating the trip log.