(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 December 2019 (26.12.2019)

WIPO | PCT

(10) International Publication Number
WO 2019/241918 A1

(51) International Patent Classification:
G01C 21/36 (2006.01)

(21) International Application Number:
PCT/CN2018/091915

(22) International Filing Date:
20 June 2018 (20.06.2018)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** METHOD, SYSTEM AND COMPUTER PROGRAM PRODUCT FOR USER MOBILITY PREDICTION

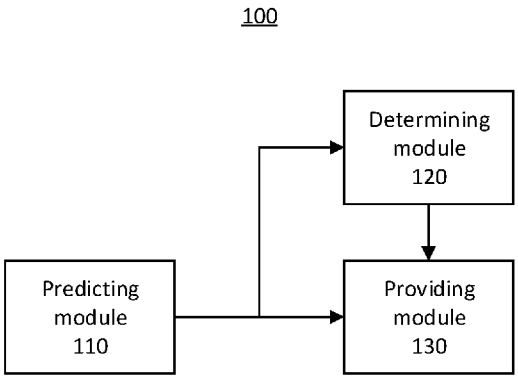

FIG. 1

(57) **Abstract:** A computer-implemented method is provided. The method comprises: acquiring a user mobility prediction for a user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination; determining whether the predicted arrival time is within a regular time segment in which a mobility pattern of the user is substantially fixed; and determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment.

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METHOD, SYSTEM AND COMPUTER PROGRAM PRODUCT FOR USER MOBILITY PREDICTION

FIELD OF THE INVENTION

[0001] The present disclosure relates in general to a field of a user mobility prediction, and in particular, to a computer-implemented method, a computing system, and a computer program product for user mobility prediction.

BACKGROUND OF THE INVENTION

[0002] There are some techniques for user mobility predictions. A user mobility prediction for a user may comprise generating a predicted destination and a predicted arrival time when arriving at the predicted destination based on historical mobility data of the user. Information associated with the user mobility prediction may always be provided to the user for reminding an event or the like.

SUMMARY OF THE INVENTION

[0003] An aspect of the present disclosure mainly aims to a user mobility prediction, as well as a computer-implemented method, a computing system, and a computer program product for user mobility prediction.

[0004] In accordance with some exemplary embodiments of the present disclosure, a computer-implemented method is provided, comprising: acquiring a user mobility prediction for a user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination; determining whether the predicted arrival time is within a regular time segment in which a mobility pattern of the user is substantially fixed; and determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment.

[0005] In accordance with some exemplary embodiments of the present disclosure, a computer-implemented method is provided, comprising: determining whether a time segment is a regular time segment in which a mobility pattern of a user is substantially fixed; in response to the time segment being a regular time segment, generating a user mobility prediction based on historical mobility data of the user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination, and the predicted arrival time is within the time segment; and providing information associated with the user mobility prediction to the user.

[0006] In accordance with some exemplary embodiments of the present disclosure, a computing system is provided, comprising: one or more processors; and one or more computer-readable memories coupled to the one or more processors, configured to store a series of computer executable instructions, wherein the series of computer executable instructions, when executed by the one or more processors, cause the one or more processors to perform any one of the above mentioned methods.

[0007] In accordance with some exemplary embodiments of the present disclosure, a computer program product is provided, comprising: a computer readable storage medium having computer executable instructions stored thereon that, when executed by one or more processors, causing the one or more processors to perform any one of the above mentioned methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above and other aspects and advantages of the present disclosure will become apparent from the following detailed description of exemplary embodiments taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the present disclosure. Note that the drawings are not necessarily drawn to scale.

[0009] Fig. 1 illustrates an exemplary block diagram showing a system associated with a method in accordance with some exemplary embodiments of the present disclosure.

[0010] Fig. 2 illustrates an exemplary block diagram showing a system associated with a method in accordance with some exemplary embodiments of the present disclosure.

[0011] Fig. 3 illustrates an exemplary flow chart showing a method in accordance with some exemplary embodiments of the present disclosure.

[0012] Fig. 4 illustrates an exemplary flow chart showing a method in accordance with some exemplary embodiments of the present disclosure.

[0013] Fig. 5 illustrates an exemplary flow chart showing a method in accordance with some exemplary embodiments of the present disclosure.

[0014] Fig. 6 illustrates an exemplary histogram showing historical mobility data in accordance with some exemplary embodiments of the present disclosure.

[0015] Fig. 7 illustrates an exemplary histogram showing historical mobility data in accordance with some exemplary embodiments of the present disclosure.

[0016] Fig. 8 illustrates an exemplary drawing showing popular locations in accordance with some exemplary embodiments of the present disclosure.

[0017] Fig. 9 illustrates an exemplary block diagram showing a general hardware environment wherein the present disclosure is applicable in accordance with some exemplary

embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] In the following detailed description, numerous specific details are set forth to provide a thorough understanding of the described exemplary embodiments. It will be apparent, however, to one skilled in the art that the described embodiments can be practiced without some or all of these specific details. In other exemplary embodiments, well known structures or process steps have not been described in detail in order to avoid unnecessarily obscuring the concept of the present disclosure.

[0019] The term "A or B" used through the specification refers to "A and B" and "A or B" rather than meaning that A and B are exclusive, unless otherwise specified.

[0020] Referring first to Fig. 1, there is shown an exemplary block diagram of a system 100 associated with a method in accordance with some exemplary embodiments of the present disclosure. System 100 is only illustrative and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein.

[0021] As shown in Fig. 1, system 100 may include a predicting module 110, a determining module 120, and a providing module 130. The predicting module 110 may be configured to generate a user mobility prediction for a user based on historical mobility data of the user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination. The historical mobility data of the user may include locations that the user visited over a past time period and at least arrival time when arriving at each of the locations. The determining module 120 may be configured to determine whether the user mobility prediction generated by the predicting module 110 is reliable. The providing module 130 may be configured to generate information associated with the user mobility prediction and provide the information to the user in response to the user mobility prediction being reliable. The information associated with the user mobility prediction may be a suggested departure time based on the predicted destination, the current location of the user, the predicted arrival time, the traffic condition, the weather condition, or the like.

[0022] Referring now to Fig. 2, there is shown an exemplary block diagram of a system 200 associated with a method in accordance with some exemplary embodiments of the present disclosure. System 200 is only illustrative and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein. Duplicate descriptions on the same steps, approaches and elements as the above will be omitted.

[0023] As shown in Fig. 2, system 200 may include a determining module 210, a predicting module 220, and a providing module 230. The determining module 210 may be

configured to determine whether a next period of time is suitable for predicting. The predicting module 220 may be configured to generate a user mobility prediction for a user based on historical mobility data of the user in response to the next period of time being suitable for predicting, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination. The providing module 230 may be configured to generate information associated with the user mobility prediction and provide the information to the user in response to the user mobility prediction being reliable. In some cases, the user mobility prediction may be transmitted to the determining module 210 for further determining whether the user mobility prediction is reliable. The determining module 210 may be further configured to determine whether the user mobility prediction is reliable. The providing module 230 may be configured in these cases to generate information associated with the user mobility prediction and provide the information to the user in response to the user mobility prediction being reliable.

[0024] Referring now to Fig. 3, there is shown an exemplary flow chart of a method 300 in accordance with some exemplary embodiments of the present disclosure. In some exemplary embodiments, method 300 may be applied to determine whether the user mobility prediction is reliable. Method 300 is only illustrative and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein.

[0025] At block 310, whether the predicted arrival time is within a regular time segment may be determined. A regular time segment may be a time segment in which a mobility pattern of the user is substantially fixed. That is, the user's mobility may repeat regularly in a regular time segment. At block 320, in response to the predicted arrival time being within a regular time segment, the user mobility prediction may be determined to be reliable.

[0026] A time segment may be time of day, day of week, day of month or day of year. Time of day may be a period of time in a day, 9:01-10:00 for example, or a point in time in a day, 9:00 for example. In addition, a time segment may occur periodically over a period of time, e.g., a past time period hereinafter. For example, a time segment may be 9:01-10:00 of each day, Friday of each week, the first day of each month, or the like. The time span of a plurality of time segments in the past time period may be different from each other.

[0027] A time segment being a regular time segment or not may be determined beforehand based on historical mobility data of the user (which will be described in more detail with reference to Figs. 6 and 7). The historical mobility data comprise locations the user visited in the time segment over a past time period and visiting frequencies that the user visited each of the locations. A visiting frequency is a number of times that the user

visited a location in the time segment over the past time period.

[0028] The past time period may be a period of time in the past, preferably in the recent past. In some cases, the past time period may not include at least one of weekends, festivals, and holidays, since the mobility pattern of the user in these days may not be such fixed as other days. For example, a time segment may be 9:01-10:00 of each working day in these cases. In other cases, the past time period may include at least one of weekends and short holidays for example, and a time segment may be 9:01-10:00 of these days.

[0029] Referring now to Fig. 4, there is shown an exemplary flow chart of a method 400 in accordance with some exemplary embodiments of the present disclosure. In some exemplary embodiments, method 400 may be applied to determine whether the user mobility prediction is reliable. Method 400 is only illustrative and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein. Duplicate descriptions on the same steps, approaches and elements as the above will be omitted.

[0030] At block 410, whether the predicted arrival time is within a regular time segment in which a mobility pattern of the user is substantially fixed may be determined. At block 420, in response to the predicted arrival time being without any regular time segment, whether the predicted destination matches a popular location for the predicted arrival time may be determined. At block 430, in response to the predicted destination matching a popular location, the user mobility prediction may be determined to be reliable.

[0031] A popular location may be a location that a group of people associated with the user like to visit in a period of time associated with the predicted arrival time. The group of people associated with the user may comprise at least one of: the user's family, the user's relative, the user's friend, the user's colleague, the user's classmate, the user's roommate, people having the same hobby as the user, people in the same age as the user, and people having similar profiles to the user.

[0032] A popular location may be determined beforehand based on historical locations over a past time period where the group of people associated with the user visited in a period of time containing the predicted arrival time (which will be described in more detail with reference to Fig. 8). Whether a location is a popular location may be determined based on a visiting frequency or a number of visiting people of the location by the group of people. For example, in response to the visiting frequency or a number of visiting people of the location by the group of people being greater than a threshold, the location is determined as a popular location. A plurality of locations may be determined respectively as a plurality of popular locations for a period of time containing the predicted arrival time, and a location may be determined as a popular location in response to being one of the plurality of popular locations.

[0033] The period of time containing the predicted arrival time may be time of day, day of week, day of month or day of year. For example, the period of time containing the predicted arrival time may be a time segment described above in some cases.

[0034] Referring now to Fig. 5, there is shown an exemplary flow chart of a method 500 in accordance with some exemplary embodiments of the present disclosure. In some exemplary embodiments, method 500 may be applied to determine whether the user mobility prediction is reliable. Method 500 is only illustrative and is not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein. Duplicate descriptions on the same steps, approaches and elements as the above will be omitted.

[0035] At block 510, whether the predicted arrival time is within a regular time segment and the predicted destination matches a popular location for the predicted arrival time may be determined. At block 520, in response to the predicted arrival time being within a regular time segment and the predicted destination matching a popular location, the user mobility prediction may be determined to be reliable. Wherein whether a time segment is a regular time segment or not may be determined beforehand based on historical mobility data of the user, and whether a location is a popular location may be determined beforehand based on historical locations where a group of people associated with the user visited in a period of time containing the predicted arrival time.

[0036] Referring now to Fig. 6, there is shown an exemplary histogram of historical mobility data 600 in accordance with some exemplary embodiments of the present disclosure. In some exemplary embodiments, historical mobility data 600 may be applied to determine whether a time segment is a regular time segment or not. Historical mobility data 600 are only illustrative and are not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein.

[0037] Three time segments 610, 620, 630 are shown in Fig. 6. In an illustrative example, historical mobility data 600 may be data over the recent past six months, time segment 610 may be 9:01-10:00 of each working day over the recent past six months, time segment 620 may be 12:01-13:00, and time segment 630 may be 20:01-21:00. The user visited four locations in time segment 610, a cafe (an example for location 1), restaurant A (an example for location 2), the user's office (an example for location 3) and restaurant B (an example for location 4) for example; three locations in time segment 620, restaurant A, restaurant C (an example for location 5) and restaurant B for example; and three locations in time segment 630, restaurant A, the user's home (an example for location 6) and restaurant B for example. It should be noted that the locations in each time segment may be all locations that the user visited in the time segment, or a predetermined number of

locations that the user visited most frequently in the time segment.

[0038] Historical mobility data 600 of the user comprise locations the user visited in the time segment over a past time period and visiting frequencies that the user visited each of the locations. A visiting frequency is a number of times that the user visited a location in the time segment over the past time period. The heights of the bars in the histogram of Fig. 6 represent the visiting frequencies of the locations.

[0039] In the exemplary historical mobility data 600 shown in Fig. 6, the visiting frequencies of locations 1 and 2 in time segment 610 may both be about 20 times, and the visiting frequencies of locations 3 and 4 in time segment 610 may be a little more than 80 times and 20 times respectively. The visiting frequencies of locations 2, 5 and 4 in time segment 620 may all be a little more than 40 times. The visiting frequency of location 2 in time segment 630 may be about 20 times, the visiting frequency of location 6 in time segment 630 may be a little more than 130 times, and the visiting frequency of location 4 in time segment 630 may be about 10 times.

[0040] In response to determining a visiting frequency of one of the locations by the user is significantly higher than other locations in a time segment over the past time period, the time segment is determined as a regular time segment. As shown in Fig. 6, since the visiting frequency of location 3 is significantly higher than other locations (i.e., locations 1, 2 and 4) in time segment 610, for example the user visited his/her office most frequently from 9:01 to 10:00 in each working day over the recent past six months and the visiting frequency of his/her office is significantly higher than other locations, time segment 610 may be determined as a regular time segment. Since the visiting frequency of location 6 is significantly higher than other locations (i.e., locations 2 and 4) in time segment 630, for example the user visited his/her home most frequently from 20:01 to 21:00 in each working day over the recent past six months and the visiting frequency of his/her office is significantly higher than other locations, time segment 630 may be determined as a regular time segment. Since there is no visiting frequency of a location in the three locations in time segment 620 being significantly higher than other locations, time segment 620 may not be determined as a regular time segment.

[0041] Some approaches may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in the time segment over the past time period, and further determine whether the time segment is a regular time segment.

[0042] One of the approaches may comprise in response to a ratio of a visiting frequency of a location that the user visited most frequently to a number of the locations being greater than a threshold, determining a visiting frequency of one of the locations is

significantly higher than other locations in the time segment over the past time period, and further determining the time segment as a regular time segment.

[0043] In the exemplary historical mobility data 600 shown in Fig. 6, the visiting frequency of location 3 (i.e., the location having the maximum visiting frequency) in time segment 610 may be 84 times, the number of the locations in the time segment is 4, then the ratio of the visiting frequency of location 3 to the number of the locations in time segment 610 may be 21. Since the visiting frequency of any one of other locations except location 3 in this time segment is smaller than the visiting frequency of location 3, the ratios associated with other locations are smaller than 21 definitely, which do not need to be calculated.

[0044] The visiting frequency of location 5 (i.e., the location having the maximum visiting frequency) in time segment 620 may be 45 times, the number of the locations in the time segment is 3, then the ratio of the visiting frequency of location 5 to the number of the locations in time segment 620 may be 15. Since the visiting frequency of any one of other locations except location 5 in this time segment is smaller than the visiting frequency of location 5, the ratios associated with other locations are smaller than 15 definitely, which do not need to be calculated.

[0045] The visiting frequency of location 6 (i.e., the location having the maximum visiting frequency) in time segment 630 may be 135 times, the number of the locations in the time segment is 3, then the ratio of the visiting frequency of location 6 to the number of the locations in time segment 630 may be 45. Since the visiting frequency of any one of other locations except location 6 in this time segment is smaller than the visiting frequency of location 6, the ratios associated with other locations are smaller than 45 definitely, which do not need to be calculated.

[0046] A threshold associated with the ratio of the visiting frequency of the location that the user visited most frequently to the number of the locations in the time segment may be determined beforehand. For example, a threshold with a value of 18 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time segment, thus time segments 610 and 630 may be determined as regular time segments and time segment 620 may not be determined as a regular time segment. For example, a threshold with a value of 30 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time segment, thus time segment 630 may be determined as a regular time segment and time segments 610 and 620 may not be determined as regular time segments.

[0047] Another of the approaches may comprise in response to a ratio of a visiting frequency of a location that the user visited most frequently to a sum of visiting frequencies of other locations being greater than a threshold, determining a visiting frequency of one of

the locations is significantly higher than other locations in the time segment over the past time period, and further determining the time segment as a regular time segment.

[0048] In the exemplary historical mobility data 600 shown in Fig. 6, the visiting frequency of location 3 (i.e., the location having the maximum visiting frequency) in time segment 610 may be 84 times, the sum of visiting frequencies of other locations in the time segment is 151, then the ratio of the visiting frequency of location 3 to the sum of visiting frequencies of other locations in time segment 610 may be 0.556. Since the visiting frequency of any one of other locations except location 3 in this time segment is smaller than the visiting frequency of location 3, the ratios associated with other locations are smaller than 0.556 definitely, which do not need to be calculated.

[0049] The visiting frequency of location 5 (i.e., the location having the maximum visiting frequency) in time segment 620 may be 45 times, the sum of visiting frequencies of other locations in the time segment is 129, then the ratio of the visiting frequency of location 5 to the sum of visiting frequencies of other locations in time segment 620 may be 0.349. Since the visiting frequency of any one of other locations except location 5 in this time segment is smaller than the visiting frequency of location 5, the ratios associated with other locations are smaller than 0.349 definitely, which do not need to be calculated.

[0050] The visiting frequency of location 6 (i.e., the location having the maximum visiting frequency) in time segment 630 may be 135 times, the sum of visiting frequencies of other locations in the time segment is 165, then the ratio of the visiting frequency of location 6 to the sum of visiting frequencies of other locations in time segment 630 may be 0.818. Since the visiting frequency of any one of other locations except location 6 in this time segment is smaller than the visiting frequency of location 6, the ratios associated with other locations are smaller than 0.818 definitely, which do not need to be calculated.

[0051] A threshold associated with the ratio of the visiting frequency of the location that the user visited most frequently to the sum of visiting frequencies of other locations in the time segment may be determined beforehand. For example, a threshold with a value of 0.5 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time segment, thus time segments 610 and 630 may be determined as regular time segments and time segment 620 may not be determined as a regular time segment. For example, a threshold with a value of 0.8 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time segment, thus time segment 630 may be determined as a regular time segment and time segments 610 and 620 may not be determined as regular time segments.

[0052] Another of the approaches may comprise in response to a ratio of a visiting frequency of a location that the user visited most frequently to a visiting frequency of a location that the user visited the second most frequently being greater than a threshold, determining a visiting frequency of one of the locations is significantly higher than other locations in the time segment over the past time period, and further determining the time segment as a regular time segment.

[0053] In the exemplary historical mobility data 600 shown in Fig. 6, the visiting frequency of location 3 (i.e., the location having the maximum visiting frequency) in time segment 610 may be 84 times, the visiting frequency of location 4 (i.e., the location that the user visited the second most frequently) in the time segment is 27, then the ratio of the visiting frequency of location 3 to the visiting frequency of location 4 in time segment 610 may be 3.11. Since the visiting frequency of any one of other locations except location 3 in this time segment is smaller than the visiting frequency of location 3, the ratios associated with other locations are smaller than 3.11 definitely, which do not need to be calculated.

[0054] The visiting frequency of location 5 (i.e., the location having the maximum visiting frequency) in time segment 620 may be 45 times, the visiting frequency of location 2 or 4 (i.e., the location that the user visited the second most frequently) in the time segment is 42, then the ratio of the visiting frequency of location 5 to the visiting frequency of location 2 or 4 in time segment 620 may be 1.07. Since the visiting frequency of any one of other locations except location 5 in this time segment is smaller than the visiting frequency of location 5, the ratios associated with other locations are smaller than 1.07 definitely, which do not need to be calculated.

[0055] The visiting frequency of location 6 (i.e., the location having the maximum visiting frequency) in time segment 630 may be 135 times, the visiting frequency of location 2 (i.e., the location that the user visited the second most frequently) in the time segment is 20, then the ratio of the visiting frequency of location 6 to the visiting frequency of location 2 in time segment 630 may be 6.75. Since the visiting frequency of any one of other locations except location 6 in this time segment is smaller than the visiting frequency of location 6, the ratios associated with other locations are smaller than 6.75 definitely, which do not need to be calculated.

[0056] A threshold associated with the ratio of the visiting frequency of the location that the user visited most frequently to the visiting frequency of the location that the user visited the second most frequently in the time segment may be determined beforehand. For example, a threshold with a value of 2 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time

segment, thus time segments 610 and 630 may be determined as regular time segments and time segment 620 may not be determined as a regular time segment. For example, a threshold with a value of 4 may be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in a time segment, thus time segment 630 may be determined as a regular time segment and time segments 610 and 620 may not be determined as regular time segments.

[0057] Referring now to Fig. 7, there is shown an exemplary histogram of historical mobility data 700 in accordance with some exemplary embodiments of the present disclosure. In some exemplary embodiments, historical mobility data 700 may be applied to determine whether a time segment is a regular time segment or not. Historical mobility data 700 are only illustrative and are not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein. Duplicate descriptions on the same steps, approaches and elements as the above will be omitted.

[0058] In the exemplary historical mobility data 600 shown in Fig. 6, the three locations for a user in time segment 620 may be a restaurant (an example for location 2), a park (an example for location 5), and a cafe (an example for location 4). The user may visit the restaurant for lunch from 12:05 to 12:22 every day, visit the park for a walk from 12:30 to 12:45 every day, and visit the cafe for a coffee from 12:50 to 12:55 every day. In this case, the mobility pattern of the user is substantially fixed in this case.

[0059] In some exemplary embodiments, in the event that there is no location having a visiting frequency significantly higher than other locations in the time segment over the past time period, the method may further comprises dividing the time segment into a plurality of sub-segments and determining whether each of the sub-segments is a regular time segment or not. As shown in Fig. 7, time segment 620 shown in Fig. 6 may be divided into three time segments 710, 720, 730. For example, historical mobility data 700 may be data over the recent past six months, time segment 710 may be 12:01 to 12:25 of each working day over the recent past six months, time segment 720 may be 12:26-12:45, and time segment 730 may be 12:46-13:00.

[0060] Although there is only one location in each of time segments 710, 720, 730 in the example shown in Fig. 7, those skilled in the art may appreciate that there may be one or more other locations in each of time segments 710, 720, 730. Those approaches described above may also be applied to determine whether a visiting frequency of one of the locations is significantly higher than other locations in the time segment over the past time period, and further determine whether the time segment is a regular time segment. In the example shown in Fig. 7, since there is only one location in each of time segments 710, 720, 730, a

visiting frequency of one of the locations is significantly higher than other locations in each of time segments 710, 720, 730, and each of time segments 710, 720, 730 may be determined as a regular time segment.

[0061] Referring now to Fig. 8, there is shown an exemplary drawing of popular locations in accordance with some exemplary embodiments of the present disclosure. These popular locations are only illustrative and are not intended to suggest any limitation as to the scope of use or functionality of embodiments of the disclosure described herein.

[0062] A popular location may be a location that a group of people associated with the user like to visit in a period of time associated with the predicted arrival time. The group of people associated with the user may be determined based on data of users, and the group of people associated with the user may comprise at least one of: the user's family, the user's relative, the user's friend, the user's colleague, the user's classmate, the user's roommate, people having the same hobby as the user, people in the same age as the user, and people having similar profiles to the user.

[0063] One or more popular locations may be determined beforehand based on historical locations over a past time period where the group of people associated with the user visited in a period of time containing the predicted arrival time. Whether a location is a popular location may be determined based on a visiting frequency or a number of visiting people of the location by the group of people. For example, in response to the visiting frequency or a number of visiting people of the location by the group of people being greater than a threshold, the location is determined as a popular location. A plurality of locations may be determined respectively as a plurality of popular locations for a period of time containing the predicted arrival time, and a location may be determined as a popular location in response to being one of the plurality of popular locations. In some cases, the visiting frequency of a location by the group of people is greater than a threshold, the location may be determined as a popular location. In some cases, the number of visiting people of a location by the group of people is greater than a threshold, the location may be determined as a popular location.

[0064] Three locations of which the visiting frequencies or the numbers of visiting people by the group of people are greater than a threshold are shown as popular locations (popular location 1, popular location 2, and popular location 3) respectively. A location (marked as "Matched") matching a popular location (popular location 1) and a location (marked as "Not matched") matching no popular location are also shown in Fig. 8.

[0065] The present disclosure may be implemented as a computer-implemented method, a computing system, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer executable

instructions thereon for causing one or more processors to carry out aspects of the present disclosure.

[0066] According to some exemplary embodiments of the present disclosure, there is provided a computer-implemented method, which comprises: determining whether a time segment is a regular time segment in which a mobility pattern of a user is substantially fixed; in response to the time segment being a regular time segment, generating a user mobility prediction based on historical mobility data of the user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination, and the predicted arrival time is within the time segment; and providing information associated with the user mobility prediction to the user.

[0067] According to some exemplary embodiments of the method, the method further comprises: determining whether the predicted destination matches a popular location for the predicted arrival time; and providing information associated with the user mobility prediction to the user in response to the time segment being a regular time segment and the predicted destination matching a popular location.

[0068] According to some exemplary embodiments of the method, the method further comprises: determining beforehand whether a time segment is a regular time segment or not based on historical mobility data of the user, wherein the time segment is time of day, day of week, day of month or day of year, and the historical mobility data comprise locations the user visited in the time segment over a past time period and visiting frequencies that the user visited each of the locations.

[0069] According to some exemplary embodiments of the method, the method further comprises: further comprising determining beforehand whether a location is a popular location or not based on historical locations where a group of people associated with the user visited in a period of time containing the predicted arrival time.

[0070] According to some exemplary embodiments of the present disclosure, there is provided a computing system, which comprises: one or more processors; and one or more computer-readable memories coupled to the one or more processors, configured to store a series of computer executable instructions, wherein the series of computer executable instructions, when executed by the one or more processors, cause the one or more processors to perform any one of the aforementioned methods.

[0071] According to some exemplary embodiments of the present disclosure, there is provided a computer program product, which comprises a computer readable storage medium having computer executable instructions stored thereon that, when executed by one or more processors, causing the one or more processors to perform any one of the aforementioned

methods.

[0072] The computer readable storage medium may be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing.

[0073] Computer executable instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. Computer executable instructions for carrying out operations of the present disclosure may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer executable instructions may execute entirely on the user's device (may be an on-vehicle device), partly on the user's device, as a stand-alone software package, partly on the user's device and partly on a remote device or entirely on the remote device or server.

[0074] Aspects of the present disclosure are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer executable instructions.

[0075] These computer executable instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0076] Fig. 9 illustrates an exemplary block diagram showing a general hardware environment 900 wherein the present disclosure is applicable in accordance with some exemplary embodiments of the present disclosure.

[0077] With reference to Fig. 9, a hardware environment 900, which is an example of the hardware device that may be applied to some aspects of the present disclosure, will now be described. The hardware environment 900 may be any machine configured to perform processing and/or calculations, may be but is not limited to a work station, a server, a desktop computer, a laptop computer, a tablet computer, a personal data assistant, a smart phone, an on-vehicle computer or any combination thereof. The aforementioned predicting module 110, 220, determining module 120, 210, and providing module 130, 230 may be wholly or at least partially implemented by the hardware environment 900 or a similar device or system.

[0078] The hardware environment 900 may comprise elements that are connected with or in communication with a bus 902, possibly via one or more interfaces. For example, the hardware environment 900 may comprise the bus 902, one or more processors 904, one or more input devices 906 and one or more output devices 908. The one or more processors 904 may be any kinds of processors, and may comprise but are not limited to one or more general-purpose processors and/or one or more special-purpose processors (such as special processing chips). The input devices 906 may be any kinds of devices that can input information to the computing device, and may comprise but are not limited to a mouse, a keyboard, a touch screen, a microphone and/or a remote control. The output devices 908 may be any kinds of devices that can present information, and may comprise but are not limited to display, a speaker, a video/audio output terminal, a vibrator and/or a printer. The hardware environment 900 may also comprise or be connected with non-transitory storage devices 910 which may be any storage devices that are non-transitory and can implement data stores, and may comprise but are not limited to a disk drive, an optical storage device, a solid-state storage, a floppy disk, a flexible disk, hard disk, a magnetic tape or any other magnetic medium, a compact disc or any other optical medium, a ROM (Read Only Memory), a RAM (Random Access Memory), a cache memory and/or any other memory chip or cartridge, and/or any other medium from which a computer may read data, instructions and/or code. The non-transitory storage devices 910 may be detachable from an interface. The non-transitory storage devices 910 may have data/instructions/code for implementing the methods and steps which are described above. The hardware environment 900 may also comprise a communication device 912. The communication device 912 may be any kinds of device or system that can enable communication with external apparatuses and/or with a network, and may comprise but are not limited to a modem, a network card, an infrared communication device, a wireless communication device and/or a chipset such as a Bluetooth™ device, 1302.11 device, WiFi device, WiMax device, cellular communication facilities and/or the like.

[0079] When the hardware environment 900 is used as an on-vehicle device, it may also

be connected to external device, for example, a GPS receiver, sensors for sensing different environmental data such as an acceleration sensor, a wheel speed sensor, a gyroscope and so on. In this way, the hardware environment 900 may, for example, receive location data and sensor data indicating the travelling situation of the vehicle. When the hardware environment 900 is used as an on-vehicle device, it may also be connected to other facilities (such as an engine system, a wiper, an anti-lock Braking System or the like) for controlling the traveling and operation of the vehicle.

[0080] In addition, the non-transitory storage device 910 may have map information and software elements so that the processor 904 may perform route guidance processing. In addition, the output device 906 may comprise a display for displaying the map, the location mark of the vehicle, images indicating the travelling situation of the vehicle and also the visual signals. The output device 906 may also comprise a speaker for audio output.

[0081] The bus 902 may include but is not limited to Industry Standard Architecture (ISA) bus, Micro Channel Architecture (MCA) bus, Enhanced ISA (EISA) bus, Video Electronics Standards Association (VESA) local bus, and Peripheral Component Interconnect (PCI) bus. Particularly, for an on-vehicle device, the bus 902 may also include a Controller Area Network (CAN) bus or other architectures designed for application on an automobile.

[0082] The hardware environment 900 may also comprise a working memory 914, which may be any kind of working memory that may store instructions and/or data useful for the working of the processor 904, and may comprise but is not limited to a random access memory and/or a read-only memory device.

[0083] Software elements may be located in the working memory 914, including but are not limited to an operating system 916, one or more application programs 918, drivers and/or other data and codes. Instructions for performing the methods and steps described in the above may be comprised in the one or more application programs 918, and the units of the aforementioned predicting module 110, 220, determining module 120, 210, and providing module 130, 230 may be implemented by the processor 904 reading and executing the instructions of the one or more application programs 918. More specifically, the aforementioned predicting module 110, 220, determining module 120, 210, and providing module 130, 230 may, for example, be implemented by the processor 904 when executing an application 918 having instructions to perform the approaches and the steps of any of the aforementioned methods including method 300, 400, 500. The executable codes or source codes of the instructions of the software elements may be stored in a non-transitory computer-readable storage medium, such as the storage device(s) 910 described above, and may be read into the working memory 914 possibly with compilation and/or installation. The executable codes or source codes of the

instructions of the software elements may also be downloaded from a remote location.

[0084] The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

[0085] Those skilled in the art may clearly know from the above embodiments that the present disclosure may be implemented by software with necessary hardware, or by hardware, firmware and the like. Based on such understanding, the embodiments of the present disclosure may be embodied in part in a software form. The computer software may be stored in a readable storage medium such as a floppy disk, a hard disk, an optical disk or a flash memory of the computer. The computer software comprises a series of instructions to make the computer (e.g., a personal computer, a service station or a network terminal) execute the method or a part thereof according to respective embodiment of the present disclosure.

[0086] The present disclosure being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present disclosure, and all such modifications as would be obvious to those skilled in the art are intended to be included within the scope of the following claims.

WHAT IS CLAIMED IS

1. A computer-implemented method, comprising:

acquiring a user mobility prediction for a user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination;

determining whether the predicted arrival time is within a regular time segment in which a mobility pattern of the user is substantially fixed; and

determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment.

2. The method according to claim 1, further comprising:

providing information associated with the user mobility prediction to the user in response to the user mobility prediction being reliable.

3. The method according to claim 1, further comprising determining beforehand whether a time segment is a regular time segment or not based on historical mobility data of the user.

4. The method according to claim 3, wherein the time segment is time of day, day of week, day of month or day of year, and the historical mobility data comprise locations the user visited in the time segment over a past time period and visiting frequencies that the user visited each of the locations.

5. The method according to claim 4, wherein a time segment is determined as a regular time segment in response to determining a visiting frequency of one of the locations by the user is significantly higher than other locations in the time segment over the past time period.

6. The method according to claim 5, wherein a visiting frequency of one of the locations is determined as significantly higher than other locations in response to at least one of:

a ratio of a visiting frequency of a location that the user visited most frequently to a number of the locations being greater than a threshold;

a ratio of a visiting frequency of a location that the user visited most frequently to a sum of visiting frequencies of other locations being greater than a threshold; and

a ratio of a visiting frequency of a location that the user visited most frequently to a visiting frequency of a location that the user visited the second most frequently being greater than a threshold.

7. The method according to claim 4, wherein the past time period does not include at least one of weekends, festivals, and holidays.

8. The method according to claim 4, wherein the locations are all locations that the user visited in the time segment, or a predetermined number of locations that the user visited most frequently in the time segment.

9. The method according to claim 5, further comprising:

in the event that there is no location having a visiting frequency significantly higher than other locations in the time segment over the past time period, dividing the time segment into a plurality of sub-segments and determining whether each of the sub-segments is a regular time segment or not.

10. The method according to claim 1, further comprising:

determining whether the predicted destination matches a popular location for the predicted arrival time in response to the predicted arrival time being without any regular time segment; and

determining the user mobility prediction to be reliable in response to the predicted destination matching a popular location.

11. The method according to claim 1, further comprising:

determining whether the predicted destination matches a popular location for the predicted arrival time; and

determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment and the predicted destination matching a popular location.

12. The method according to claim 10, wherein a popular location is determined beforehand based on historical locations where a group of people associated with the user visited in a period of time containing the predicted arrival time.

13. The method according to claim 12, wherein a location is determined as a popular location in response to a visiting frequency or a number of visiting people of the location by the group of people being greater than a threshold.

14. The method according to claim 12, wherein the group of people associated with the user comprise at least one of: the user's family, the user's relative, the user's friend, the user's colleague, the user's classmate, the user's roommate, people having the same hobby as the user, people in the same age as the user, and people having similar profiles to the user.

15 A computer-implemented method, comprising:

determining whether a time segment is a regular time segment in which a mobility pattern of a user is substantially fixed;

in response to the time segment being a regular time segment, generating a user mobility prediction based on historical mobility data of the user, wherein the user mobility prediction includes a predicted destination and a predicted arrival time when arriving at the predicted destination, and the predicted arrival time is within the time segment; and

providing information associated with the user mobility prediction to the user.

16. The method according to claim 15, further comprising:

determining whether the predicted destination matches a popular location for the predicted arrival time; and

providing information associated with the user mobility prediction to the user in response to the time segment being a regular time segment and the predicted destination matching a popular location.

17. The method according to claim 15, further comprising determining beforehand whether a time segment is a regular time segment or not based on historical mobility data of the user, wherein the time segment is time of day, day of week, day of month or day of year, and the historical mobility data comprise locations the user visited in the time

segment over a past time period and visiting frequencies that the user visited each of the locations.

18 The method according to claim 16, further comprising determining beforehand whether a location is a popular location or not based on historical locations where a group of people associated with the user visited in a period of time containing the predicted arrival time.

19. A computing system, comprising:

one or more processors; and

one or more computer-readable memories coupled to the one or more processors, configured to store a series of computer executable instructions,

wherein the series of computer executable instructions, when executed by the one or more processors, cause the one or more processors to perform the method of any one of claims 1-18.

20. A computer program product, comprising a computer readable storage medium having computer executable instructions stored thereon that, when executed by one or more processors, causing the one or more processors to perform the method of any one of claims 1-18.

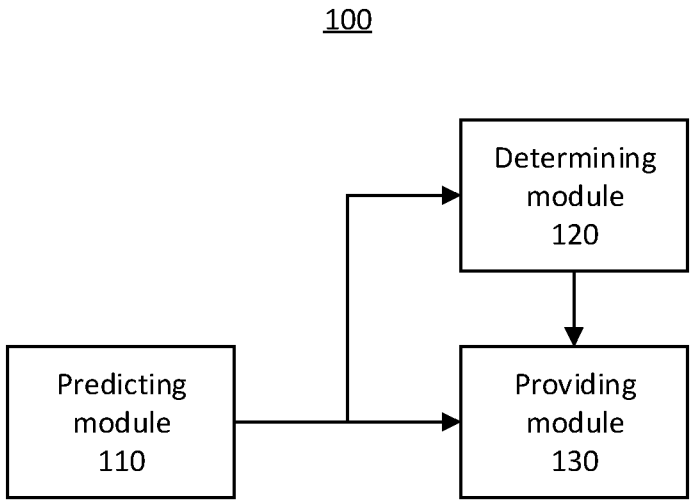
100
Determining module 120
Predicting module 110
Providing module 130

FIG. 1

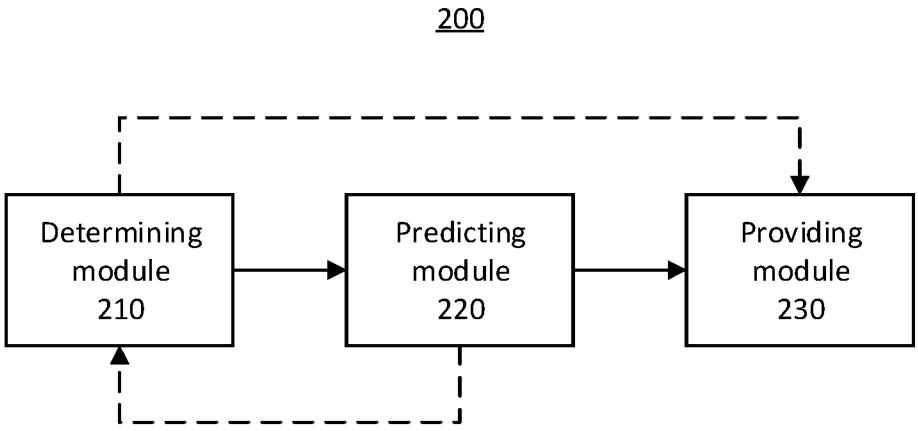
200
Determining module 210
Predicting module 220
Providing module 230

FIG. 2

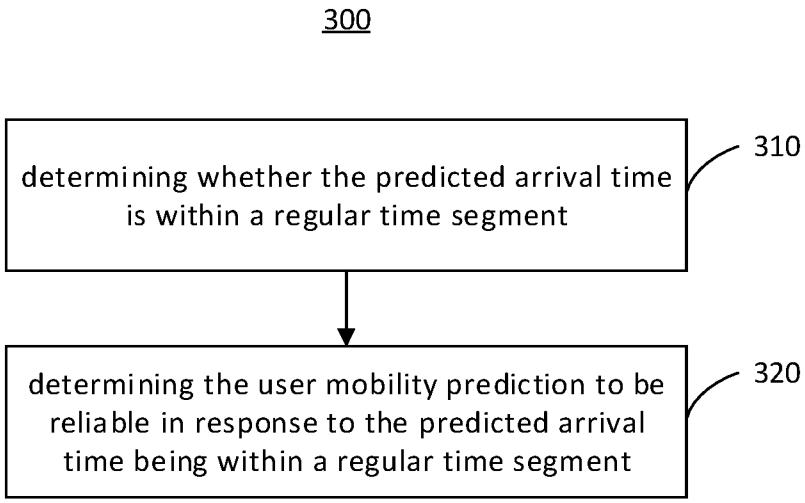
300
determining whether the predicted arrival time is within a regular time segment
310
determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment
320

FIG. 3

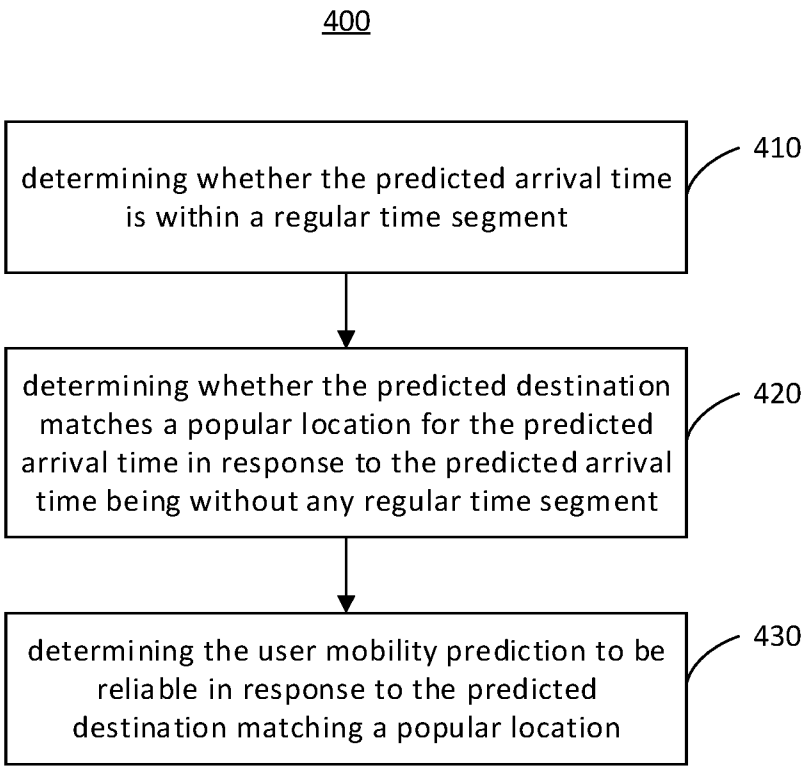
400
determining whether the predicted arrival time is within a regular time segment
410
determining whether the predicted destination matches a popular location for the predicted arrival time in response to the predicted arrival time being without any regular time segment
420
determining the user mobility prediction to be reliable in response to the predicted destination matching a popular location
430

FIG. 4

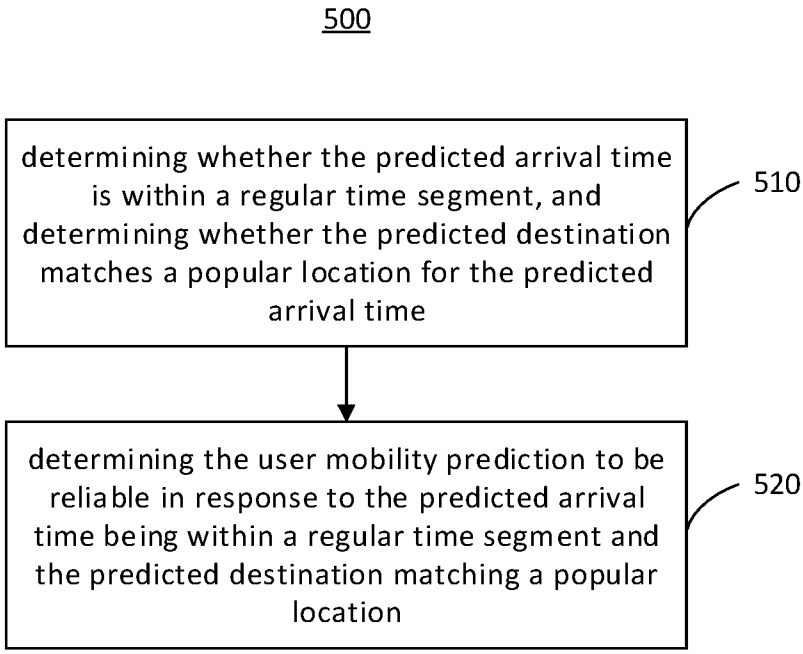
500
determining whether the predicted arrival time is within a regular time segment, and determining whether the predicted destination matches a popular location for the predicted arrival time
510
determining the user mobility prediction to be reliable in response to the predicted arrival time being within a regular time segment and the predicted destination matching a popular location
520

FIG. 5

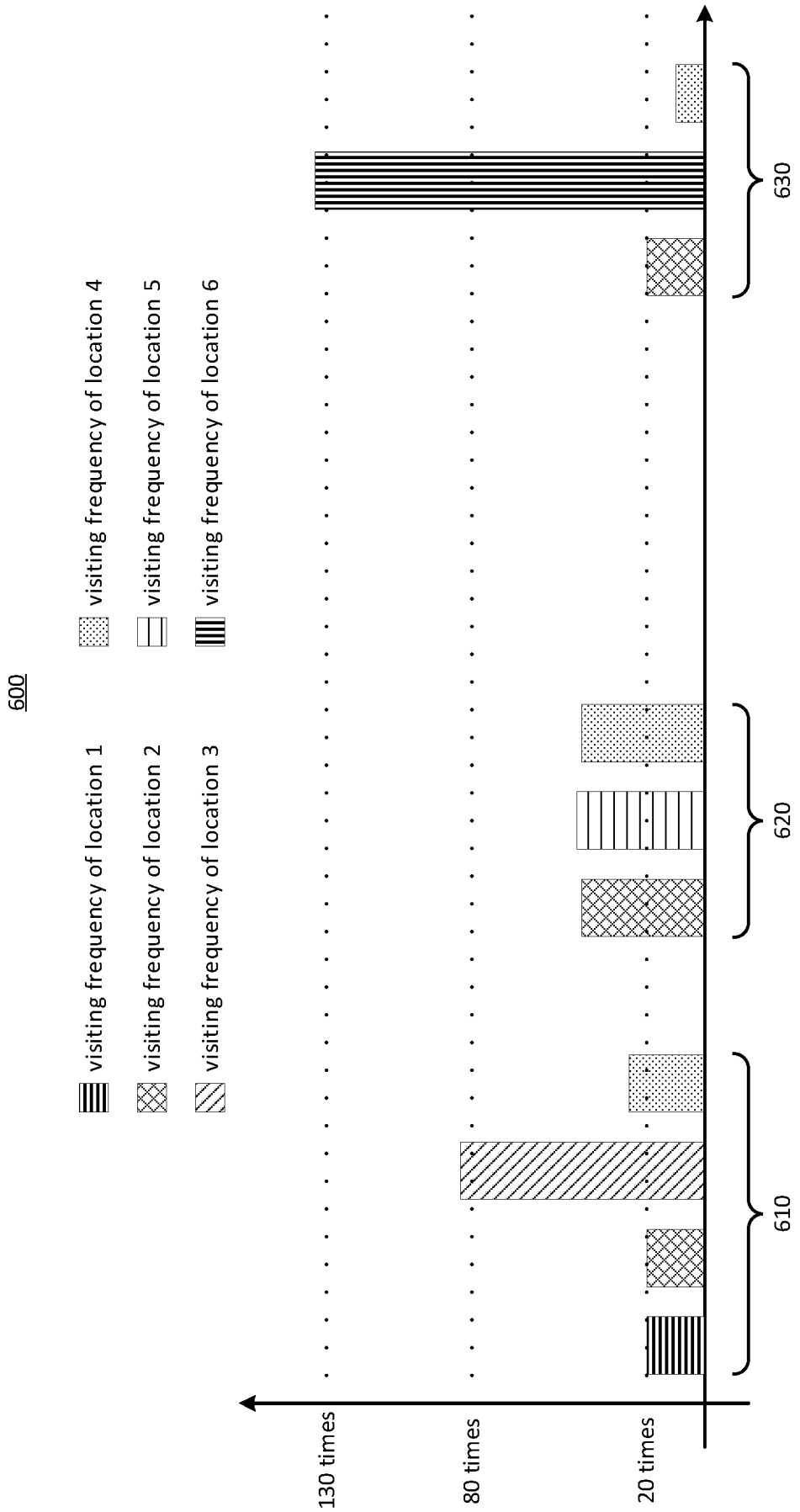
600
visiting frequency of location 1
visiting frequency of location 2
visiting frequency of location 3
visiting frequency of location 4
visiting frequency of location 5
visiting frequency of location 6
130 times
80 times
20 times
610
620
630

FIG. 6

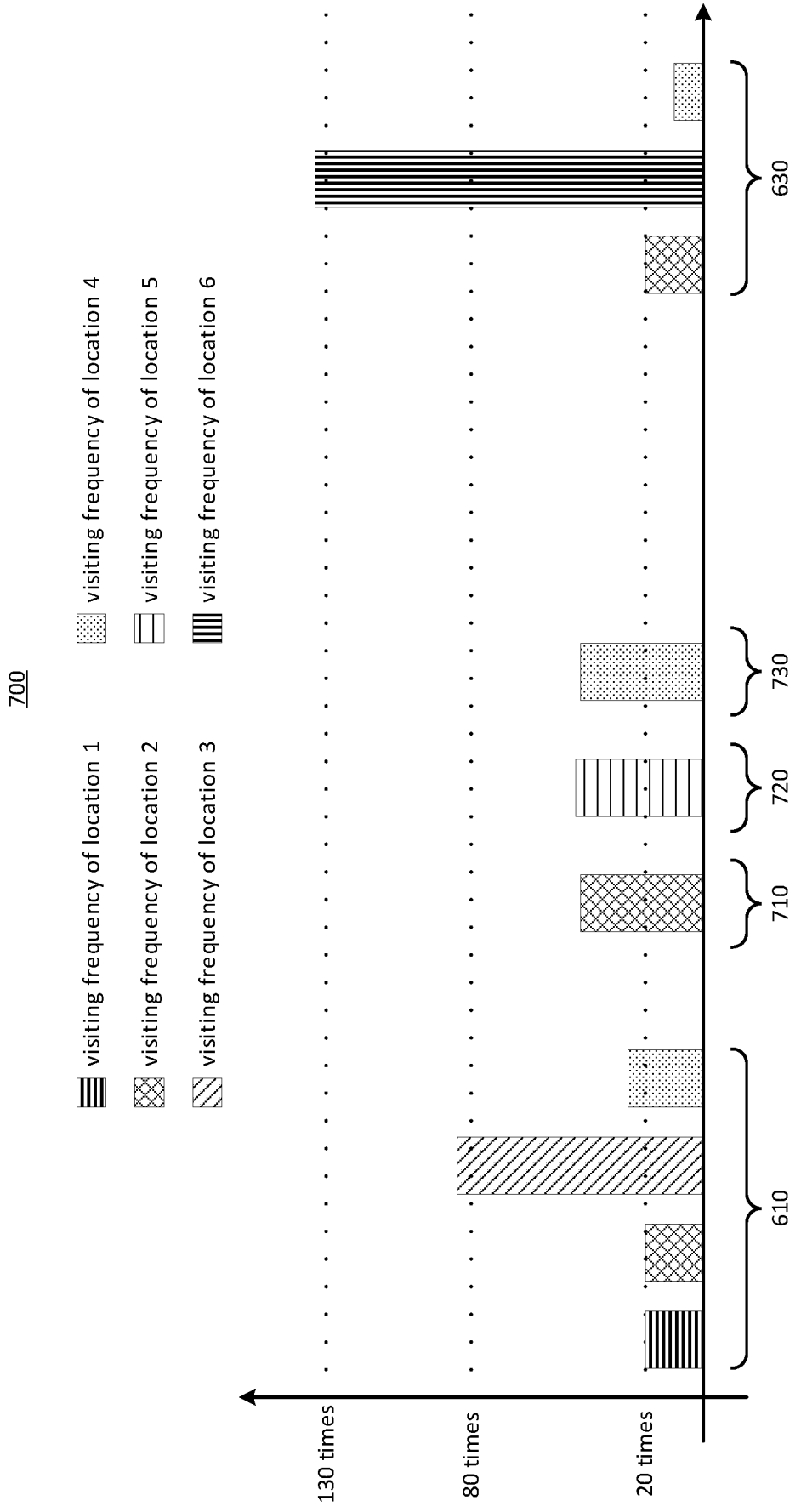
700
visiting frequency of location 1
visiting frequency of location 2
visiting frequency of location 3
visiting frequency of location 4
visiting frequency of location 5
visiting frequency of location 6
130 times
80 times
20 times
610
710
720
730
630

FIG. 7

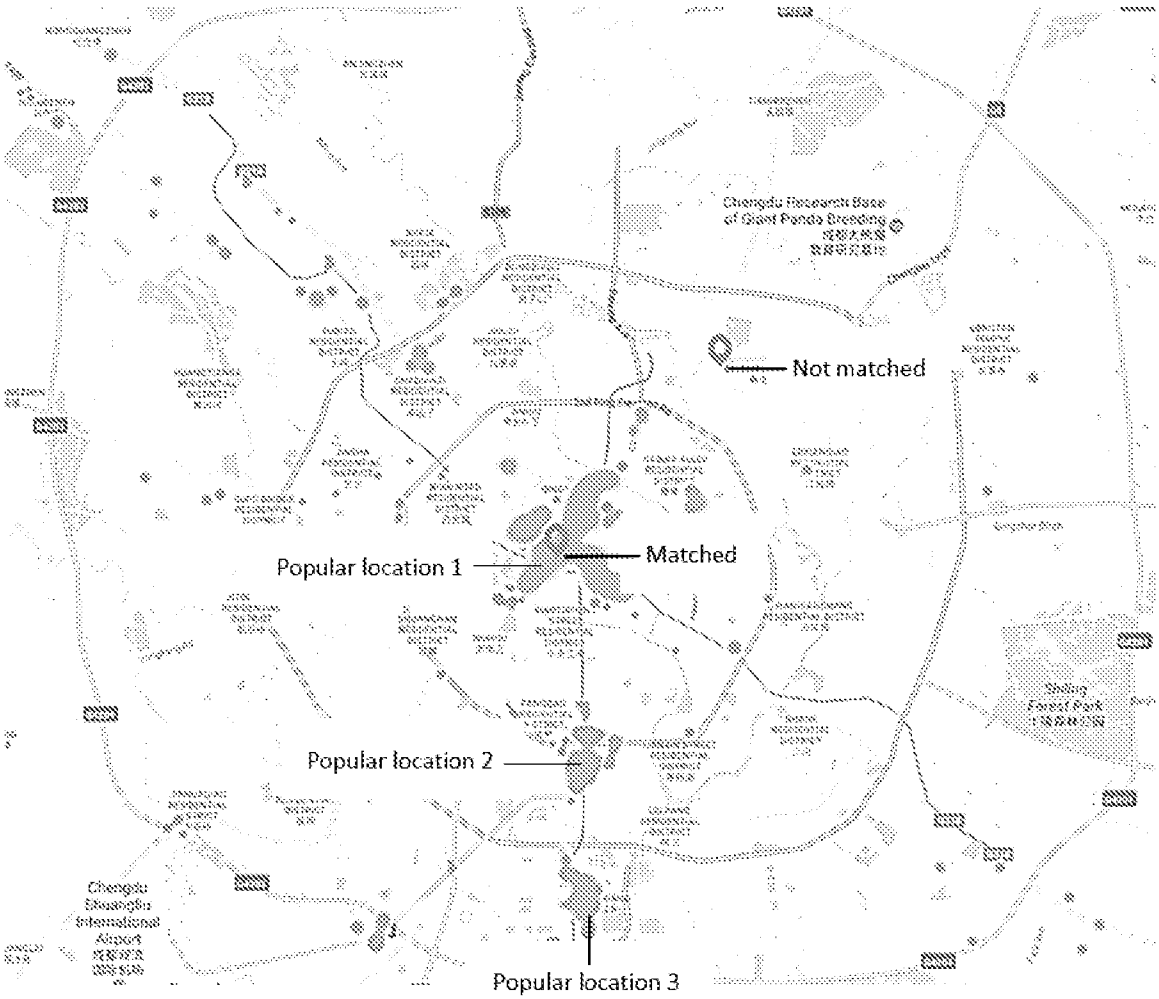
Not matched
Matched
Popular location 1
Popular location 2
Popular location 3

FIG. 8

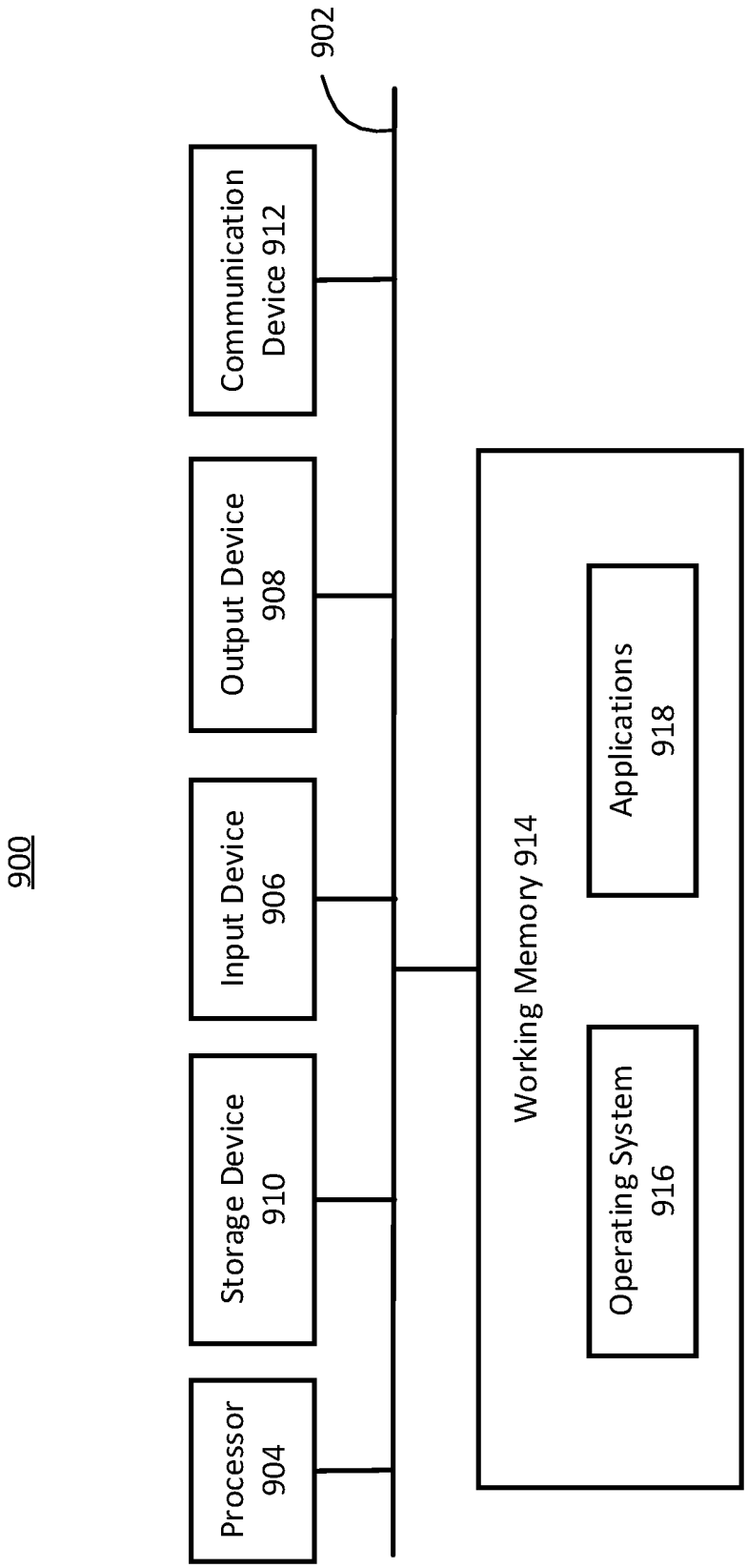
900
902
Processor 904
Storage Device 910
Input Device 906
Output Device 908
Communication Device 912
Working Memory 914
Operating System 916
Applications 918

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/091915

A. CLASSIFICATION OF SUBJECT MATTER

G01C 21/36(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01C; G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC: mobility, prediction, user, destination, arrival, time, segment, period, reliable, pattern, historical, visit, frequency, location, past,threshold

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011137834 A1 (IDE, NAOKI ET AL.) 09 June 2011 (2011-06-09) description, paragraphs [0014]-[0015]	1-20
A	US 2005251325 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 10 November 2005 (2005-11-10) the whole document	1-20
A	US 2013252638 A1 (YANG, JUN ET AL.) 26 September 2013 (2013-09-26) the whole document	1-20
A	CN 104833365 A (HUAWEI TECHNOLOGIES CO., LTD.) 12 August 2015 (2015-08-12) the whole document	1-20

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2019	**19 March 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**GAO,Fei**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53961608**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/091915

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2011137834	A1	09 June 2011	JP	2011118777	A	16 June 2011
				CN	102087722	A	08 June 2011
US	2005251325	A1	10 November 2005	AU	2003275550	A1	04 May 2004
				WO	2004034725	A1	22 April 2004
				EP	1551195	A1	06 July 2005
				JP	2009008684	A	15 January 2009
US	2013252638	A1	26 September 2013		None		
CN	104833365	A	12 August 2015	WO	2015120746	A1	20 August 2015