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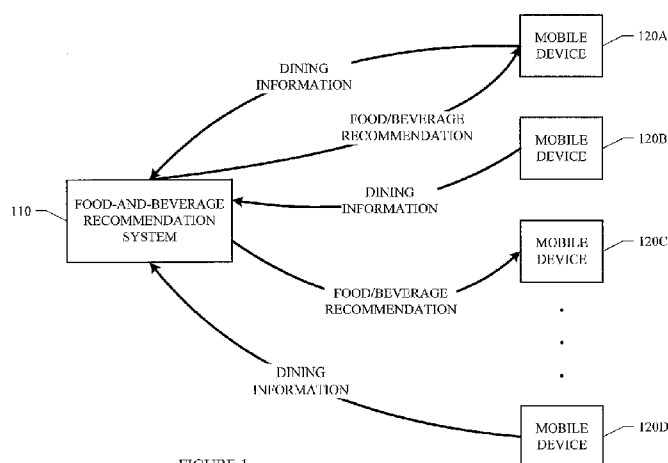


FIGURE 1

(57) Abstract: Particular embodiments extract a plurality of users, a plurality of establishments, and a plurality of items from dining information provided by at least one of the plurality of users, each of the plurality of establishments sells food or beverage; construct a user-establishment matrix, a user-item matrix, and an establishment-item matrix using the plurality of users, the plurality of establishments, and the plurality of items; generate a user latent representation for the plurality of users, an establishment latent representation for the plurality of establishments, and an item latent representation for the plurality of items; and compute one or more correlations using the user latent representation, the establishment latent representation, or the item latent representation, wherein each of the one or more correlations is between two users, two establishments, two items, one user and one establishment, one of user and one item, or one establishment and one item.

MOBILE-BASED REAL-TIME FOOD-AND-BEVERAGE RECOMMENDATION SYSTEM

INVENTOR

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RELATED APPLICATIONS

[1] This is a PCT application claiming priority to a U.S. Non-provisional Patent Application No. 12/941,842 filed on November 8, 2010 which is in its entirety incorporated herein by reference.

TECHNICAL FIELD

[2] The present disclosure generally relates to a product and/or service recommendation system and more specifically relates to recommending food and/or beverages to consumers in real time via mobile devices.

BACKGROUND

[3] Consumers often receive recommendations on products and/or services from various sources, such as merchants, experts, advertisers, friends, families, etc. Such recommendations may be provided to the consumers at any time, but usually when the consumers express interest in certain types of products or services. Sometimes, the recommended products or services are determined based on what specific products or services the other consumers, who are also interested in similar types of products or services, have purchased in the past. For example, when a consumer purchases a book from amazon.com, an Internet-based merchant that sells various types of products, amazon.com may recommend to the consumer other books that have been purchased by other consumers who have also purchased, in the past, the same book that is currently being purchased by the consumer. As another example, when a consumer wants to purchase a digital camera, he may ask his friends what brands and models of digital cameras they have purchased and make a selection based on his friends' recommendations.

SUMMARY

[4] The present disclosure generally relates to a product and/or service recommendation system and more specifically relates to recommending food and/or beverages to consumers in real time via mobile devices.

5 **[5]** In particular embodiments, a food-and-beverage recommendation system may recommend food and/or beverages to consumers in real time and via their mobile devices. In particular embodiments, the consumers are the users of the food-and-beverage recommendation system. In particular embodiments, when the users dine out, they may provide information on the establishments at where they have dined and the food and/or beverages they have ordered to the food-and-beverage recommendation system. The food-and-beverage recommendation system may process the information to determine recommendations for food and/or beverages with respect to specific establishments and/or specific users. In particular embodiments, the food and/or beverage recommendations may be provided to the individual users when they are dining at specific establishments.

[6] In particular embodiments, a food-and-beverage recommendation system extracts a plurality of users, a plurality of establishments, and a plurality of items from dining information provided by at least one of the plurality of users. Each of the plurality of establishments sells food or beverage and has been visited by at least one of the plurality of users. Each of the plurality of items is food or beverage sold at at least one of the plurality of establishments and has been ordered by at least one of the plurality of users at at least one of the plurality of establishments. The food-and-beverage recommendation system constructs a user-establishment matrix, a user-item matrix, and an establishment-item matrix using the plurality of users, the plurality of establishments, and the plurality of items; generates a user latent representation for the plurality of users, an establishment latent representation for the plurality of establishments, and an item latent representation for the plurality of items; and computes one or more correlations using the user latent representation, the establishment latent representation, or the item latent representation, wherein each of the one or more correlations is between two of the plurality of users, two of the plurality of establishments, two of the plurality of items, one of the plurality of users and one of the plurality of establishments, one of the plurality of users and one of the plurality of items, or one of the plurality of establishments and one of the plurality of items.

[7] In particular embodiments, the food-and-beverage recommendation system receives a recommendation request from a mobile device associated a first one of the plurality of

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users at a first one of the plurality of establishment; determines one or more item recommendations with respect to the first user and the first establishment using the plurality of user-user correlations, the plurality of establishment-establishment correlations, the plurality of item-item correlations, the plurality of user-establishment correlations, the plurality of user-item correlations, and the plurality of establishment-item correlations; and transmits the one or more item recommendations to the mobile device.

[8] These and other features, aspects, and advantages of the disclosure are described in more detail below in the detailed description and in conjunction with the following figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[9] FIGURE 1 illustrates an example system for providing real-time food and/or beverage recommendations to users of a food-and-beverage recommendation system.

[10] FIGURE 2 illustrates an example method for providing real-time food and/or beverage recommendations to users of a food-and-beverage recommendation system.

[11] FIGURE 3 illustrates an example network environment.

[12] FIGURE 4 illustrates an example computer system.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[13] The present disclosure is now described in detail with reference to a few embodiments thereof as illustrated in the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, the present disclosure may be practiced without some or all of these specific details. In other instances, well known process steps and/or structures have not been described in detail in order not to unnecessarily obscure the present disclosure. In addition, while the disclosure is described in conjunction with the particular embodiments, it should be understood that this description is not intended to limit the disclosure to the described embodiments. To the contrary, the description is intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the disclosure as defined by the appended claims.

[14] There are various Internet-based resources (e.g., yelp® at “www.yelp.com” and Yahoo!® Local at “local.yahoo.com”) that provide their users with reviews and recommendations on business establishments, such as restaurants, fast food stores, beverage houses, etc. The recommendations are often determined based on the available user reviews. For example, an establishment that has received good reviews from some users may be recommended to other users. However, the quality of such recommendations suffer from a lack of a sufficient number of reviews provided by a sufficient number of users to a sufficient number of establishments. In the first place, not many people are willing to spend the time and effort to write reviews. Moreover, for those people who do write reviews, usually, each person is able to write only a few reviews to a few establishments. As a result, only a limited number of establishments (e.g., famous, popular, or large establishments) have received user reviews, and among these, each establishment only has a limited number of user reviews. Consequently, the quality of the recommendations is limited by the small number of user reviews provided to the small number of establishments. In addition, since these reviews are provided to the individual establishments, the recommendations are at establishment level as well (i.e., recommending the individual establishments instead of the individual food and/or beverage items sold at the establishments).

[15] To improve the quality of recommendations on the business establishments and the items sold at these establishments, particular embodiments extract a set of users, a set of establishments, and a set of items from dining information provided by the users. Particular embodiments construct a user-establishment matrix, a user-item matrix, and an establishment-

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any recommendations, or request and receive food and/or beverage recommendations from food-and-beverage recommendation system 110 without providing any information.

[19] In particular embodiments, a person needs to become a registered user of food-and-beverage recommendation system 110 before he can use the services provided by food-and-beverage recommendation system 110. In particular embodiments, each registered user of food-and-beverage recommendation system 110 has a user identifier that uniquely identifies that user. Optionally, each registered user of food-and-beverage recommendation system 110 may have a password associated with his unique user identifier so that the user may access food-and-beverage recommendation system 110 securely.

[20] In particular embodiments, each registered user of food-and-beverage recommendation system 110 has a user profile that includes information concerning the user, such as, for example and without limitation, the user's demographic information (e.g., address, gender, age, family status, work status, etc.), the mobile device (e.g., mobile device 120) associated with the user, the user's culinary preferences (e.g., favorite restaurants, food, beverages, etc.), and other features. In particular embodiments, the mobile device associated with each registered user of food-and-beverage recommendation system 110 may have a mobile-device identifier that uniquely identifies that mobile device, and the mobile-device identifier may be included in the user profile of the user associated with that mobile device. For example, a mobile device may be identified by the unique telephone number assigned to it, or its unique serial number.

[21] FIGURE 2 illustrates an example method for providing real-time food and/or beverage recommendations to users of a food-and-beverage recommendation system. Particular embodiments may receive dining information from individual mobile devices associated with individual users, as illustrated in STEP 201. In particular embodiments, these users are registered users of a food-and-beverage recommendation system, and the dining information is transmitted to the food-and-beverage recommendation system from the mobile devices associated with the user via wireless connections.

[22] In particular embodiments, the dining information may include the establishments the users have visited and the food and/or beverage items the users have ordered at the individual establishments. Optionally, the dining information may include, for example and without limitations, the type (e.g., restaurant, café, beverage house, bar, etc.), food category (e.g., seafood, barbecue, steak house, vegetarian, etc.), ethnicity (e.g., Cajun food, Italian food, French

food, Chinese food, Mediterranean food), location (e.g., city and state, zip code, latitude and longitude), or user rating (e.g., a numeric score) of each establishment. The dining information may also include, for example and without limitations, the type (e.g., drink, appetizer, side dish, bread, main course, dessert, etc.), price, or user rating (e.g., a numeric score) of each food or beverage item. Any information concerning an establishment or a food or beverage item may be considered dining information and provided to the food-and-beverage recommendation system.

[23] There are various methods for a user to provide dining information to the food-and-beverage recommendation system, and the present disclosure contemplates any suitable method. In particular embodiments, a user may provide dining information in text format. The user may manually input the dining information as texts (e.g., the name of an establishment, and the name, price, and user rating of each food or beverage item ordered at the establishment) into his mobile device and transmit the texts to the food-and-beverage recommendation system. The food-and-beverage recommendation system may process the texts to extract the appropriate dining information.

[24] In particular embodiments, a user may provide dining information as digital images. If the user's mobile device has a built-in digital camera, the user may take digital photos of the individual food and/or beverage items ordered at an establishment (perhaps with the permission of the establishment). The user may transmit the digital photos (e.g., the digital photos stored as image files) to the food-and-beverage recommendation system. The food-and-beverage recommendation system may apply various image processing and recognition techniques to automatically determine individual food and/or beverage items from the digital photos.

[25] Often, a digital photo has associated metadata, one of which may be the geographic location (e.g., represented as latitude and longitude) where the digital photo is taken. In particular embodiments, the food-and-beverage recommendation system may use the geographic location metadata of a digital photo to automatically determine the location, and consequently the establishment itself, where the photo is taken. In this case, it is not necessary for the user to provide information (e.g., the name) of the establishment where the user has visited separately. The establishment where the user has ordered the food or beverage item in the digital photo may be automatically determined from the metadata (e.g., the geographic location metadata) of the digital photo.

[26] If the user takes a digital photo of a food or beverage item in an establishment and transmits that digital photo to the food-and-beverage recommendation system while the user is

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well as the establishment itself, from the digital image of the dining bill. If the dining bill is scanned as texts, the food-and-beverage recommendation system may parse the texts to extract the establishment, as well as the individual food and/or beverage items and their prices.

[30] In particular embodiments, a user may provide dining information as digital recordings. If the user's mobile device has a built-in digital recorder, the user may record his conversation with a service personnel (e.g., a waiter or waitress) as the user orders food and/or beverages at an establishment (perhaps with the permission of the service personnel). The user may transmit the digital recording (e.g., the digital recording stored as an audio file) to the food-and-beverage recommendation system. The food-and-beverage recommendation system may apply various voice processing and speech recognition techniques to automatically determine the individual food and/or beverage items ordered by the user from the digital recording.

[31] In particular embodiments, a user may provide dining information as bar codes. In order to more accurately and conveniently identify the individual establishments and the individual food or beverage items, in particular embodiments, a unique bar code may be attached to each item on the menu of each establishment or to other suitable places. The corresponding information may be stored in a database associated with the food-and-beverage recommendation system. If a user's mobile device has a built-in bar-code scanner, the user may scan the bar codes corresponding to the specific food and/or beverage items he has ordered at an establishment, and transmits the bar codes to the food-and-beverage recommendation system. The food-and-beverage recommendation system may process the bar codes to determine which specific establishment the user has visited and which specific food and/or beverage items the user has ordered at that establishment based on the information stored in the database.

[32] The food-and-beverage recommendation system may support any combination of the various methods that enable its users to provide dining information to it. In particular embodiments, over some period of time, the food-and-beverage recommendation system may receive and collect dining information from many users visiting many establishments and ordering many food and/or beverage items. Particular embodiments may mine the dining information collected from the users over some period of time by conducting tri-partite graph mining or tensor factorization for the purpose of determining food and/or beverage recommendations for the individual users. In particular embodiments, the purposes of mining the dining information are to profile each user with his favorite food and/or beverage items or favorite food and/or beverage types and his authority score distribution on the food and/or beverage items or types, and profile each establishment with its strength distribution on the food

[37] The following TABLE 1 illustrates an example user-establishment matrix $M^{U,E}$. For example, TABLE 1 indicates that user u_1 has visited establishment e_1 three times, establishment e_3 twelve times, but has never visited establishment e_2 . Similarly, user u_2 has visited establishment e_2 , but has never visited establishments e_1 , e_3 and e_{n2} . In particular

5 embodiments, it is possible that a user from user set U has never provided dining information with respect to any establishment from establishment set E . In this case, all entries in user-establishment matrix $M^{U,E}$ corresponding to this user may be 0.

	e_1	e_2	e_3	...	e_{n2}
u_1	3	0	12		9
u_2	0	2	0		0
u_3	1	5	0		0
...					
u_{n1}	0	0	2		21

TABLE 1: an example user-establishment matrix

[38] In particular embodiments, user-item matrix $M^{U,I}$ is a $n3 \times n1$ integer matrix.

10 Each entry $m_{u,i}$ represents the number of times a corresponding user u has ordered a corresponding food or beverage item i . In particular embodiments, the same food or beverage item may be offered at multiple establishments, and a user may order a specific food or beverage item at any establishment. In particular embodiments, the numbers may be determined from the tuples.

15 [39] The following TABLE 2 illustrates an example user-item matrix $M^{U,I}$. For example, TABLE 2 indicates that user u_1 has ordered item i_2 four times, but has never ordered item i_1 . Similarly, user u_3 has ordered item i_1 eight times, but has never ordered item i_2 . In particular embodiments, it is possible that a user from user set U has never provided dining information concerning any item from item set I . In this case, all entries in user-item matrix

20 $M^{U,I}$ corresponding to this user may be 0.

	i_1	i_2	i_3	...	i_{n3}
u_1	0	4	17		0
u_2	4	0	2		0

u_3	8	0	7		25
...					
u_{n1}	0	9	0		0

TABLE 2: an example user-item matrix

[40] In particular embodiments, establishment-item matrix $M^{E,I}$ is a $n3 \times n2$ binary or Boolean matrix. Each entry $m_{e,i}$ represents whether a corresponding establishment e offers a corresponding food or beverage item i . For example, the value 1 may indicate that an establishment offers an item, and a value 0 may indicate that an establishment does not offer an item. In particular embodiments, the same food or beverage item may be offered at multiple establishments. For example, multiple restaurants may offer club sandwich, spaghetti with meat balls, iced tea, or tiramisu. In particular embodiments, the values may be determined from the tuples.

[41] The following TABLE 3 illustrates an example establishment-item matrix $M^{E,I}$. For example, TABLE 3 indicates that establishment e_1 offers item i_2 , but does not offer items i_1 , i_3 , and i_{n3} . Similarly, establishment e_3 offers items i_1 and i_3 , but has never ordered item i_2 and i_{n3} . In particular embodiments, it is possible that an item from item set I is not offered by any establishment from establishment set E . In this case, all entries in establishment-item matrix $M^{E,I}$ corresponding to this item may be 0.

	i_1	i_2	i_3	$\dots$	i_{n3}
e_1	0	1	0		0
e_2	0	1	1		1
e_3	1	0	1		0
$\dots$					
e_{n2}	0	0	0		1

TABLE 3: an example establishment-item matrix

[42] Particular embodiments may generate a user latent representation for the set of users, an establishment latent representation for the set of establishment, and an item latent representation for the set of items using user-establishment matrix $M^{U,E}$, user-item matrix $M^{U,I}$, and establishment-item matrix $M^{E,I}$, as illustrated in STEP 204. In particular embodiments, the user latent representation is the representation of the set of users, U , in a

establishments, E , in a latent establishment space; and item latent representation is the representation of the set of items, I , in a latent item space.

[43] Particular embodiments may generate the three types of latent representations by optimizing the following loss function using stochastic gradient descent:

$$\begin{aligned} & \ell(M^{U,E}, U^{d1} W^{U,E} E^{d2}) + \alpha_1 \ell(M^{E,I}, E^{d2} W^{E,I} I^{d3}) + \\ 5 \quad & \alpha_2 \ell(M^{U,I}, U^{d1} W^{U,I} I^{d3}) + \beta_1 \|U^{d1}\|_p + \beta_2 \|E^{d2}\|_p + \beta_3 \|I^{d3}\|_p. \end{aligned} \quad (1)$$

[44] In EQUATION (1), $\ell(\cdot)$ may be any loss function, such as, for example and without limitation, mean squared error, etc. U^{d1} is a $d1 \times n1$ matrix representing the $n1$ users in the latent $d1$ -dimensional user space, where $d1 \geq 1$; E^{d2} is a $d2 \times n2$ matrix representing the $n2$ establishments in the latent $d2$ -dimensional establishment space, where $d2 \geq 1$; E^{d2} is the transpose matrix of E^{d2} ; and I^{d3} is a $d3 \times n3$ matrix representing the $n3$ food and/or beverage items in the latent $d3$ -dimensional item space, where $d3 \geq 1$. $W^{U,E}$ is a $d1 \times d2$ covariance matrix for user and establishment; $W^{E,I}$ is a $d2 \times d3$ covariance matrix for establishment and item; and $W^{U,I}$ is a $d1 \times d3$ covariance matrix for user and item. $\|U^{d1}\|_p$ is the p-norm regularization for U^{d1} ; $\|E^{d2}\|_p$ is the p-norm regularization for E^{d2} ; and $\|I^{d3}\|_p$ is the p-norm regularization for I^{d3} . α_1 , α_2 , β_1 , β_2 , and β_3 are real-value parameters that may be empirically tuned.

[45] In particular embodiments, the outputs of EQUATION (1) are U^{d1} , E^{d2} , I^{d3} , $W^{U,E}$, $W^{U,I}$, and $W^{E,I}$. Based on these six matrices, particular embodiments may user-user correlations, establishment-establishment correlations, item-item correlations, user-establishment correlations, user-item correlations, and establishment-item correlations, as illustrated in STEP 205. Particular embodiments may profile each user and each establishment based on these correlations.

[46] In particular embodiments, the user-user correlations indicate how similar one user is to another user in terms of their food and/or beverage preferences (e.g., flavor, taste, cuisine type, etc.). In particular embodiments, for any user, $u_j \in U$, his $d1$ -dimensional latent

vector, $\vec{U}_j$, is the j^{th} row in matrix U^{d1} . For any two users, $u_{j1} \in U$ and $u_{j2} \in U$, their correlation, or similarity in terms of food and/or beverage preferences, may be computed as:

$$sim(u_{j1}, u_{j2}) = \vec{U}_{j1} \bullet \vec{U}_{j2}. \quad (2)$$

[47] In particular embodiments, the establishment-establishment correlations indicate how similar one establishment is to another establishment in terms of the food and/or beverages they offer (e.g., flavor, taste, cuisine type, etc.). In particular embodiments, for any establishment, $e_j \in E$, its $d2$ -dimensional latent vector, $\vec{E}_j$, is the j^{th} row in matrix E^{d2} . For any two establishments, $e_{j1} \in E$ and $e_{j2} \in E$, their correlation, or similarity in terms of food and/or beverages they offer, may be computed as:

$$sim(e_{j1}, e_{j2}) = \vec{E}_{j1} \bullet \vec{E}_{j2}. \quad (3)$$

[48] In particular embodiments, the item-item correlations indicate how similar one food or beverage item is to another item in terms of their flavor, type, category, taste, presentation, etc. In particular embodiments, for any item, $i_j \in I$, its $d3$ -dimensional latent vector, $\vec{I}_j$, is the j^{th} row in matrix I^{d3} . For any two items, $i_{j1} \in I$ and $i_{j2} \in I$, their correlation, or similarity in terms of flavor, taste, type, category, etc., may be computed as:

$$sim(i_{j1}, i_{j2}) = \vec{I}_{j1} \bullet \vec{I}_{j2}. \quad (4)$$

[49] In particular embodiments, the user-establishment correlations indicate how well a user likes an establishment. In particular embodiments, for any user-establishment pair, $u_j \in U$ and $e_k \in E$, their correlation may be computed as:

$$sim(u_j, e_k) = \vec{U}_j W^{U,E} \vec{E}_k. \quad (5)$$

[50] In particular embodiments, the user-item correlations indicate how well a user likes a food or beverage item. In particular embodiments, for any user-item pair, $u_j \in U$ and $i_k \in I$, their correlation may be computed as:

$$sim(u_j, i_k) = \vec{U}_j W^{U,I} \vec{I}_k. \quad (6)$$

[51] In particular embodiments, the establishment-item correlations indicate how good

establishment-item pair, $e_j \in E$ and $i_k \in I$, their correlation may be computed as:

$$\text{sim}(e_j, i_k) = \bar{E}_j W^{E,I} \bar{I}_k. \quad (7)$$

[52] In particular embodiments, there may be any number of features or attributes associated with each user, each establishment, and each food or beverage item. For example, the features associated with each user may include, without limitation, the user's preferred ingredients, spices, food types, or beverage types, whether the user is vegetarian, concerned about presentation, environment, service quality, or availability of entertainment, etc. The features associated with each establishment may include, without limitation, the cuisine ethnicity or type of the establishment (e.g., Chinese food, Italian food, seafood, barbecue, vegetarian food, pizza, etc.), average price per entry, environment, popularity, etc. The features associated with each item may include, without limitation, the item's flavor (e.g., spicy or mild), ingredients, price, popularity, etc.

[53] Suppose there are $f1$ user features, $f2$ establishment features, and $f3$ establishment features, where $f1 \geq 1$, $f2 \geq 1$, and $f3 \geq 1$. Particular embodiments may optionally construct a user-feature matrix, $M^{U,F}$, an establishment-feature matrix, $M^{E,F}$, and an item-feature matrix, $M^{I,F}$. In particular embodiments, $M^{U,F}$ is a $f1 \times n1$ matrix, and each entry in $M^{U,F}$ may have a value 1 or a value 0 indicating a corresponding user does or does not have a corresponding user feature respectively. $M^{E,F}$ is a $f2 \times n2$ matrix, and each entry in $M^{E,F}$ may have a value 1 or a value 0 indicating a corresponding establishment does or does not have a corresponding establishment feature respectively. $M^{I,F}$ is a $f3 \times n3$ matrix, and each entry in $M^{I,F}$ may have a value 1 or a value 0 indicating a corresponding item does or does not have a corresponding item feature respectively.

[54] If matrices $M^{U,F}$, $M^{E,F}$, and $M^{I,F}$ are available, particular embodiments may incorporate them in EQUATION (1). Consequently EQUATION (1) may be modified as the following:

$$\begin{aligned} & \ell(M^{U,E}, U^{d1} W^{U,E} E^{d2}) + \alpha 1 \ell(M^{E,I}, E^{d2} W^{E,I} I^{d3}) + \\ & \alpha 2 \ell(M^{U,I}, U^{d1} W^{U,I} I^{d3}) + \beta 1 \|U^{d1}\|_p + \beta 2 \|E^{d2}\|_p + \beta 3 \|I^{d3}\|_p + \\ & \alpha 3 \ell(U^{d1}, M^{U,F} Z^U) + \alpha 4 \ell(E^{d2}, M^{E,F} Z^E) + \alpha 5 \ell(I^{d3}, M^{I,F} Z^I) \end{aligned} \quad (8)$$

[55] In EQUATION (8), Z^U is a $f1 \times d1$ matrix projecting a $f1$ -dimensional user feature vector to a $d1$ -dimensional user latent vector; Z^E is a $f2 \times d2$ matrix projecting a $f2$ -dimensional establishment feature vector to a $d2$ -dimensional establishment latent vector; and Z^I is a $f3 \times d3$ matrix projecting a $f3$ -dimensional item feature vector to a $d3$ -dimensional item latent vector. The outputs of EQUATION (8) are again U^{d1} , E^{d2} , I^{d3} , $W^{U,E}$, $W^{U,I}$, and $W^{E,I}$, which may be used to determine various types of correlations as described above.

[56] Particular embodiments may make real-time food and/or beverage item recommendations to individual users when the users are at specific establishments using the user-user, establishment-establishment, item-item, user-establishment, user-item, and establishment-item correlations, as illustrated in STEP 206. In particular embodiments, suppose a user, $u_j \in U$, is visiting an establishment, $e_k \in E$. Before placing an order, user u_j may wish to receive recommendations on food and/or beverage items offered by establishment e_k . In particular embodiments, user u_j may send a request to the food-and-beverage recommendation system via his mobile device. In response to this request, the food-and-beverage recommendation system may determine which establishment user u_j is currently visiting. User u_j may specify the establishment he is currently visiting in the request. Alternatively, the food-and-beverage recommendation system may determine the establishment user u_j is currently visiting using the signals received from the mobile device of user u_j . In particular embodiments, the food-and-beverage recommendation system determines recommendations on the food and/or beverage items offered at establishment e_k specifically for user u_j using the user-user, establishment-establishment, item-item, user-establishment, user-item, and establishment-item correlations. The recommendations may be transmitted to the mobile device of user u_j .

[57] In particular embodiments, a food-and-beverage recommendation system may continuously receive and collect dining information from its users and make food and/or

beverage recommendations to its users. As additional dining information is collected, STEPS 202-205 of FIGURE 2 may be performed from time to time or as needed to obtain updated matrices U^{d1} , E^{d2} , I^{d3} , $W^{U,E}$, $W^{U,I}$, and $W^{E,I}$, which may then be used to determine recommendations for specific users visiting specific establishments.

5 **[58]** In addition, new people may become registered users of the food-and-beverage recommendation system be added to user set U ; conversely, existing users may be removed from user set U if they no longer desire to receive the services provided by the food-and-beverage recommendation system. Similarly, new establishments may be added to establishment set E , and existing establishments may be removed from establishment set E . New food and/or
10 beverage items may be added to item set I , and existing items may be removed from item set I . As these changes occur, STEPS 202-205 of FIGURE 2 may be performed as needed to obtain updated matrices U^{d1} , E^{d2} , I^{d3} , $W^{U,E}$, $W^{U,I}$, and $W^{E,I}$.

[59] In particular embodiments, the users of a food-and-beverage recommendation system may belong to a social network. A social network, in general, is a social structure made up of entities, such as individuals or organizations, that are connected by one or more types of interdependency or relationships, such as friendship, kinship, common interest, financial exchange, dislike, or relationships of beliefs, knowledge, or prestige. In more recent years, social networks have taken advantage of the Internet. There are social-networking systems existing on the Internet in form of social-networking websites. Such social-networking websites enable their members, who are commonly referred to as website users, to perform various social activities. For example, the social-networking website operated by Facebook, Inc. at www.facebook.com enables its users to communicate with their friends via emails, instant messages, or blog postings, organize social events, share photos, receive news of their friends or interesting events, play games, etc.

[60] Particular embodiments may be implemented in a network environment. FIGURE 3 illustrates an example network environment 300. Network environment 300 includes a network 310 coupling one or more servers 320 and one or more clients 330 to each other. In particular embodiments, network 310 is an intranet, an extranet, a virtual private network (VPN), a local area network (LAN), a wireless LAN (WLAN), a wide area network (WAN), a metropolitan area network (MAN), a communications network, a satellite network, a portion of

the Internet, or another network 310 or a combination of two or more such networks 310. The present disclosure contemplates any suitable network 310.

[61] One or more links 350 couple servers 320 or clients 330 to network 310. In particular embodiments, one or more links 350 each includes one or more wired, wireless, or optical links 350. In particular embodiments, one or more links 350 each includes an intranet, an extranet, a VPN, a LAN, a WLAN, a WAN, a MAN, a communications network, a satellite network, a portion of the Internet, or another link 350 or a combination of two or more such links 350. The present disclosure contemplates any suitable links 350 coupling servers 320 and clients 330 to network 310.

[62] In particular embodiments, each server 320 may be a unitary server or may be a distributed server spanning multiple computers or multiple datacenters. Servers 320 may be of various types, such as, for example and without limitation, web server, news server, mail server, message server, advertising server, file server, application server, exchange server, database server, or proxy server. In particular embodiments, each server 320 may include hardware, software, or embedded logic components or a combination of two or more such components for carrying out the appropriate functionalities implemented or supported by server 320. For example, a web server is generally capable of hosting websites containing web pages or particular elements of web pages. More specifically, a web server may host HTML files or other file types, or may dynamically create or constitute files upon a request, and communicate them to clients 330 in response to HTTP or other requests from clients 330. A mail server is generally capable of providing electronic mail services to various clients 330. A database server is generally capable of providing an interface for managing data stored in one or more data stores.

[63] In particular embodiments, each client 330 may be an electronic device including hardware, software, or embedded logic components or a combination of two or more such components and capable of carrying out the appropriate functionalities implemented or supported by client 330. For example and without limitation, a client 330 may be a desktop computer system, a notebook computer system, a netbook computer system, a handheld electronic device, or a mobile telephone. A client 330 may enable a network user at client 330 to access network 310. A client 330 may have a web browser, such as Microsoft Internet Explorer or Mozilla Firefox, and may have one or more add-ons, plug-ins, or other extensions, such as Google Toolbar or Yahoo Toolbar. A client 330 may enable its user to communicate with other users at other clients 330. The present disclosure contemplates any suitable clients 330.

[64] In particular embodiments, one or more data storages 340 may be

communicatively linked to one or more servers 320 via one or more links 350. In particular embodiments, data storages 340 may be used to store various types of information. In particular embodiments, the information stored in data storages 340 may be organized according to specific data structures. Particular embodiments may provide interfaces that enable servers 320 or clients 5 330 to manage (e.g., retrieve, modify, add, or delete) the information stored in data storage 340.

[65] In particular embodiments, a server 320 may include a food-and-beverage recommendation system 322. Food-and-beverage recommendation system 322 may include hardware, software, or embedded logic components or a combination of two or more such components for carrying out the appropriate functionalities implemented or supported by food- and-beverage recommendation system 322. In particular embodiments, food-and-beverage 10 recommendation system 322 may implement the functionalities illustrated in FIGURE 2.

[66] Particular embodiments may be implemented on one or more computer systems. FIGURE 4 illustrates an example computer system 400. In particular embodiments, one or more 15 computer systems 400 perform one or more steps of one or more methods described or illustrated herein. In particular embodiments, one or more computer systems 400 provide functionality described or illustrated herein. In particular embodiments, software running on one or more computer systems 400 performs one or more steps of one or more methods described or illustrated herein or provides functionality described or illustrated herein. Particular 20 embodiments include one or more portions of one or more computer systems 400.

[67] This disclosure contemplates any suitable number of computer systems 400. This disclosure contemplates computer system 400 taking any suitable physical form. As example and not by way of limitation, computer system 400 may be an embedded computer system, a system-on-chip (SOC), a single-board computer system (SBC) (such as, for example, a 25 computer-on-module (COM) or system-on-module (SOM)), a desktop computer system, a laptop or notebook computer system, an interactive kiosk, a mainframe, a mesh of computer systems, a mobile telephone, a personal digital assistant (PDA), a server, or a combination of two or more of these. Where appropriate, computer system 400 may include one or more computer systems 400; be unitary or distributed; span multiple locations; span multiple machines; or reside in a 30 cloud, which may include one or more cloud components in one or more networks. Where appropriate, one or more computer systems 400 may perform without substantial spatial or temporal limitation one or more steps of one or more methods described or illustrated herein. As an example and not by way of limitation, one or more computer systems 400 may perform in real

time or in batch mode one or more steps of one or more methods described or illustrated herein. One or more computer systems 400 may perform at different times or at different locations one or more steps of one or more methods described or illustrated herein, where appropriate.

[68] In particular embodiments, computer system 400 includes a processor 402, memory 404, storage 406, an input/output (I/O) interface 408, a communication interface 410, and a bus 412. Although this disclosure describes and illustrates a particular computer system having a particular number of particular components in a particular arrangement, this disclosure contemplates any suitable computer system having any suitable number of any suitable components in any suitable arrangement.

[69] In particular embodiments, processor 402 includes hardware for executing instructions, such as those making up a computer program. As an example and not by way of limitation, to execute instructions, processor 402 may retrieve (or fetch) the instructions from an internal register, an internal cache, memory 404, or storage 406; decode and execute them; and then write one or more results to an internal register, an internal cache, memory 404, or storage 406. In particular embodiments, processor 402 may include one or more internal caches for data, instructions, or addresses. The present disclosure contemplates processor 402 including any suitable number of any suitable internal caches, where appropriate. As an example and not by way of limitation, processor 402 may include one or more instruction caches, one or more data caches, and one or more translation lookaside buffers (TLBs). Instructions in the instruction caches may be copies of instructions in memory 404 or storage 406, and the instruction caches may speed up retrieval of those instructions by processor 402. Data in the data caches may be copies of data in memory 404 or storage 406 for instructions executing at processor 402 to operate on; the results of previous instructions executed at processor 402 for access by subsequent instructions executing at processor 402 or for writing to memory 404 or storage 406; or other suitable data. The data caches may speed up read or write operations by processor 402. The TLBs may speed up virtual-address translation for processor 402. In particular embodiments, processor 402 may include one or more internal registers for data, instructions, or addresses. The present disclosure contemplates processor 402 including any suitable number of any suitable internal registers, where appropriate. Where appropriate, processor 402 may include one or more arithmetic logic units (ALUs); be a multi-core processor; or include one or more processors 402. Although this disclosure describes and illustrates a particular processor, this disclosure contemplates any suitable processor.

[70] In particular embodiments, memory 404 includes main memory for storing

instructions for processor 402 to execute or data for processor 402 to operate on. As an example and not by way of limitation, computer system 400 may load instructions from storage 406 or another source (such as, for example, another computer system 400) to memory 404. Processor 402 may then load the instructions from memory 404 to an internal register or internal cache. To
5 execute the instructions, processor 402 may retrieve the instructions from the internal register or internal cache and decode them. During or after execution of the instructions, processor 402 may write one or more results (which may be intermediate or final results) to the internal register or internal cache. Processor 402 may then write one or more of those results to memory 404. In particular embodiments, processor 402 executes only instructions in one or more internal
10 registers or internal caches or in memory 404 (as opposed to storage 406 or elsewhere) and operates only on data in one or more internal registers or internal caches or in memory 404 (as opposed to storage 406 or elsewhere). One or more memory buses (which may each include an address bus and a data bus) may couple processor 402 to memory 404. Bus 412 may include one or more memory buses, as described below. In particular embodiments, one or more memory
15 management units (MMUs) reside between processor 402 and memory 404 and facilitate accesses to memory 404 requested by processor 402. In particular embodiments, memory 404 includes random access memory (RAM). This RAM may be volatile memory, where appropriate. Where appropriate, this RAM may be dynamic RAM (DRAM) or static RAM (SRAM). Moreover, where appropriate, this RAM may be single-ported or multi-ported RAM.
20 The present disclosure contemplates any suitable RAM. Memory 404 may include one or more memories 404, where appropriate. Although this disclosure describes and illustrates particular memory, this disclosure contemplates any suitable memory.

[71] In particular embodiments, storage 406 includes mass storage for data or instructions. As an example and not by way of limitation, storage 406 may include an HDD, a
25 floppy disk drive, flash memory, an optical disc, a magneto-optical disc, magnetic tape, or a Universal Serial Bus (USB) drive or a combination of two or more of these. Storage 406 may include removable or non-removable (or fixed) media, where appropriate. Storage 406 may be internal or external to computer system 400, where appropriate. In particular embodiments, storage 406 is non-volatile, solid-state memory. In particular embodiments, storage 406 includes
30 read-only memory (ROM). Where appropriate, this ROM may be mask-programmed ROM, programmable ROM (PROM), erasable PROM (EPROM), electrically erasable PROM (EEPROM), electrically alterable ROM (EAROM), or flash memory or a combination of two or more of these. This disclosure contemplates mass storage 406 taking any suitable physical form.

FIG. 10

Storage 406 may include one or more storage control units facilitating communication between processor 402 and storage 406, where appropriate. Where appropriate, storage 406 may include one or more storages 406. Although this disclosure describes and illustrates particular storage, this disclosure contemplates any suitable storage.

5 [72] In particular embodiments, I/O interface 408 includes hardware, software, or both providing one or more interfaces for communication between computer system 400 and one or more I/O devices. Computer system 400 may include one or more of these I/O devices, where appropriate. One or more of these I/O devices may enable communication between a person and computer system 400. As an example and not by way of limitation, an I/O device may include a
10 keyboard, keypad, microphone, monitor, mouse, printer, scanner, speaker, still camera, stylus, tablet, touch screen, trackball, video camera, another suitable I/O device or a combination of two or more of these. An I/O device may include one or more sensors. This disclosure contemplates any suitable I/O devices and any suitable I/O interfaces 408 for them. Where appropriate, I/O interface 408 may include one or more device or software drivers enabling processor 402 to
15 drive one or more of these I/O devices. I/O interface 408 may include one or more I/O interfaces 408, where appropriate. Although this disclosure describes and illustrates a particular I/O interface, this disclosure contemplates any suitable I/O interface.

[73] In particular embodiments, communication interface 410 includes hardware, software, or both providing one or more interfaces for communication (such as, for example,
20 packet-based communication) between computer system 400 and one or more other computer systems 400 or one or more networks. As an example and not by way of limitation, communication interface 410 may include a network interface controller (NIC) or network adapter for communicating with an Ethernet or other wire-based network or a wireless NIC (WNIC) or wireless adapter for communicating with a wireless network, such as a WI-FI
25 network. This disclosure contemplates any suitable network and any suitable communication interface 410 for it. As an example and not by way of limitation, computer system 400 may communicate with an ad hoc network, a personal area network (PAN), a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), or one or more portions of the Internet or a combination of two or more of these. One or more portions of one
30 or more of these networks may be wired or wireless. As an example, computer system 400 may communicate with a wireless PAN (WPAN) (such as, for example, a BLUETOOTH WPAN), a WI-FI network, a WI-MAX network, a cellular telephone network (such as, for example, a Global System for Mobile Communications (GSM) network), or other suitable wireless network

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implementing any suitable storage. In particular embodiments, a computer-readable storage medium implements one or more portions of processor 402 (such as, for example, one or more internal registers or caches), one or more portions of memory 404, one or more portions of storage 406, or a combination of these, where appropriate. In particular embodiments, a
5 computer-readable storage medium implements RAM or ROM. In particular embodiments, a computer-readable storage medium implements volatile or persistent memory. In particular embodiments, one or more computer-readable storage media embody software. Herein, reference to software may encompass one or more applications, bytecode, one or more computer programs, one or more executables, one or more instructions, logic, machine code, one or more
10 scripts, or source code, and vice versa, where appropriate. In particular embodiments, software includes one or more application programming interfaces (APIs). This disclosure contemplates any suitable software written or otherwise expressed in any suitable programming language or combination of programming languages. In particular embodiments, software is expressed as source code or object code. In particular embodiments, software is expressed in a higher-level
15 programming language, such as, for example, C, Perl, or a suitable extension thereof. In particular embodiments, software is expressed in a lower-level programming language, such as assembly language (or machine code). In particular embodiments, software is expressed in JAVA. In particular embodiments, software is expressed in Hyper Text Markup Language (HTML), Extensible Markup Language (XML), or other suitable markup language.

20 [77] The present disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments herein that a person having ordinary skill in the art would comprehend. Similarly, where appropriate, the appended claims encompass all changes, substitutions, variations, alterations, and modifications to the example embodiments
25 herein that a person having ordinary skill in the art would comprehend.

CLAIMS

What is claimed is:

1. A method comprising: by one or more computing devices,
5 extracting a plurality of users, a plurality of establishments, and a plurality of items from dining information provided by at least one of the plurality of users, wherein:
each of the plurality of establishments sells food or beverage and has been visited by at least one of the plurality of users; and
each of the plurality of items is food or beverage sold at at least one of the
10 plurality of establishments and has been ordered by at least one of the plurality of users at at least one of the plurality of establishments;
constructing a user-establishment matrix, a user-item matrix, and an establishment-item matrix using the plurality of users, the plurality of establishments, and the plurality of items;
generating a user latent representation for the plurality of users, an establishment latent
15 representation for the plurality of establishments, and an item latent representation for the plurality of items; and
computing one or more correlations using the user latent representation, the establishment latent representation, or the item latent representation, wherein each of the one or more correlations is between two of the plurality of users, two of the plurality of establishments, two
20 of the plurality of items, one of the plurality of users and one of the plurality of establishments, one of the plurality of users and one of the plurality of items, or one of the plurality of establishments and one of the plurality of items.
2. The method of Claim 1, further comprising:
25 receiving a recommendation request from a mobile device associated a first one of the plurality of users at a first one of the plurality of establishment;
determining one or more item recommendations with respect to the first user and the first establishment using the one or more correlations; and
transmitting the one or more item recommendations to the mobile device.
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3. The method of Claim 1, wherein generating the user latent representation, the establishment latent representation, and the item latent representation comprises:
applying a loss function to the user-establishment matrix, the user-item matrix, and the

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establishment-item matrix; and

optimizing the loss function using stochastic gradient descent.

4. The method of Claim 1, further comprising:

5 constructing a user-feature matrix, an establishment-feature matrix, and an item-feature matrix;

wherein generating the user latent representation, the establishment latent representation, and the item latent representation comprises:

10 applying a loss function to the user-establishment matrix, the user-item matrix, the establishment-item matrix, the user-feature matrix, the establishment-feature matrix, and the item-feature matrix; and

optimizing the loss function using stochastic gradient descent.

5. The method of Claim 1, further comprising:

15 receiving the dining information from one or more mobile devices associated with the at least one of the plurality of users; and

determining one or more locations of the one or more mobile devices, respectively, when the one or more mobile devices transmit the dining information.

20 6. The method of Claim 1, wherein the dining information comprises one or more digital images of at least one of the plurality of menu items, one or more digital images of one or more bills from at least one of the plurality of establishments, or one or more digital recordings of one or more conversations between at least one of the plurality of users and one or more employees of at least one of the plurality of establishments.

25 7. The method of Claim 1, further comprising:

extracting a plurality of tuples from the dining information, wherein each of the plurality of tuples comprises one of the plurality of users, one of the plurality of establishments the one user has visited, and one of the plurality of items the one user has ordered at the one establishment; and

30 extracting the plurality of establishments and the plurality of items from the plurality of tuples.

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8. A system comprising:
a memory comprising instructions executable by one or more processors; and
the one or more processors coupled to the memory and operable to execute the
instructions, the one or more processors being operable when executing the instructions to:

- 5 extract a plurality of users, a plurality of establishments, and a plurality of items
from dining information provided by at least one of the plurality of users, wherein:
each of the plurality of establishments sells food or beverage and has been
visited by at least one of the plurality of users; and
each of the plurality of items is food or beverage sold at at least one of the
10 plurality of establishments and has been ordered by at least one of the plurality of
users at at least one of the plurality of establishments;
construct a user-establishment matrix, a user-item matrix, and an establishment-
item matrix using the plurality of users, the plurality of establishments, and the plurality
of items;
15 generate a user latent representation for the plurality of users, an establishment
latent representation for the plurality of establishments, and an item latent representation
for the plurality of items; and
compute one or more correlations using the user latent representation, the
establishment latent representation, or the item latent representation, wherein each of the
20 one or more correlations is between two of the plurality of users, two of the plurality of
establishments, two of the plurality of items, one of the plurality of users and one of the
plurality of establishments, one of the plurality of users and one of the plurality of items,
or one of the plurality of establishments and one of the plurality of items.

25 9. The system of Claim 8, wherein the one or more processors are further operable
when executing the instructions to:

- receive a recommendation request from a mobile device associated a first one of the
plurality of users at a first one of the plurality of establishment;
determine one or more item recommendations with respect to the first user and the first
30 establishment using the one or more correlations; and
transmit the one or more item recommendations to the mobile device.

10. The system of Claim 8, wherein generating the user latent representation, the

establishment latent representation, and the item latent representation comprises:

apply a loss function to the user-establishment matrix, the user-item matrix, and the establishment-item matrix; and

optimize the loss function using stochastic gradient descent.

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11. The system of Claim 8, wherein the one or more processors are further operable when executing the instructions to:

construct a user-feature matrix, an establishment-feature matrix, and an item-feature matrix;

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wherein generating the user latent representation, the establishment latent representation, and the item latent representation comprises:

apply a loss function to the user-establishment matrix, the user-item matrix, the establishment-item matrix, the user-feature matrix, the establishment-feature matrix, and the item-feature matrix; and

15

optimize the loss function using stochastic gradient descent.

12. The system of Claim 8, wherein the one or more processors are further operable when executing the instructions to:

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receive the dining information from one or more mobile devices associated with the at least one of the plurality of users; and

determine one or more locations of the one or more mobile devices, respectively, when the one or more mobile devices transmit the dining information.

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13. The system of Claim 8, wherein the dining information comprises one or more digital images of at least one of the plurality of menu items, one or more digital images of one or more bills from at least one of the plurality of establishments, or one or more digital recordings of one or more conversations between at least one of the plurality of users and one or more employees of at least one of the plurality of establishments.

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14. The system of Claim 8, wherein the one or more processors are further operable when executing the instructions to:

extract a plurality of tuples from the dining information, wherein each of the plurality of tuples comprises one of the plurality of users, one of the plurality of establishments the one user

has visited, and one of the plurality of items the one user has ordered at the one establishment;
and

extract the plurality of establishments and the plurality of items from the plurality of
tuples.

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15. One or more computer-readable non-transitory storage media embodying software
operable when executed by one or more computer systems to:

extract a plurality of users, a plurality of establishments, and a plurality of items from
dining information provided by at least one of the plurality of users, wherein:

10 each of the plurality of establishments sells food or beverage and has been visited
by at least one of the plurality of users; and

each of the plurality of items is food or beverage sold at at least one of the
plurality of establishments and has been ordered by at least one of the plurality of users at
at least one of the plurality of establishments;

15 construct a user-establishment matrix, a user-item matrix, and an establishment-item
matrix using the plurality of users, the plurality of establishments, and the plurality of items;

generate a user latent representation for the plurality of users, an establishment latent
representation for the plurality of establishments, and an item latent representation for the
plurality of items; and

20 compute one or more correlations using the user latent representation, the establishment
latent representation, or the item latent representation, wherein each of the one or more
correlations is between two of the plurality of users, two of the plurality of establishments, two
of the plurality of items, one of the plurality of users and one of the plurality of establishments,
one of the plurality of users and one of the plurality of items, or one of the plurality of
25 establishments and one of the plurality of items.

16. The media of Claim 15, wherein the software is further operable when executed
by the one or more computer systems to:

30 receive a recommendation request from a mobile device associated a first one of the
plurality of users at a first one of the plurality of establishment;

determine one or more item recommendations with respect to the first user and the first
establishment using the one or more correlations; and

transmit the one or more item recommendations to the mobile device.

17. The media of Claim 15, wherein generating the user latent representation, the establishment latent representation, and the item latent representation comprises:

5 apply a loss function to the user-establishment matrix, the user-item matrix, and the establishment-item matrix; and
 optimize the loss function using stochastic gradient descent.

18. The media of Claim 15, wherein the software is further operable when executed by the one or more computer systems to:

10 construct a user-feature matrix, an establishment-feature matrix, and an item-feature matrix;

 wherein generating the user latent representation, the establishment latent representation, and the item latent representation comprises:

15 apply a loss function to the user-establishment matrix, the user-item matrix, the establishment-item matrix, the user-feature matrix, the establishment-feature matrix, and the item-feature matrix; and
 optimize the loss function using stochastic gradient descent.

19. The media of Claim 15, wherein the software is further operable when executed by the one or more computer systems to:

20 receive the dining information from one or more mobile devices associated with the at least one of the plurality of users; and

 determine one or more locations of the one or more mobile devices, respectively, when the one or more mobile devices transmit the dining information.

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20. The media of Claim 15, wherein the software is further operable when executed by the one or more computer systems to:

30 extract a plurality of tuples from the dining information, wherein each of the plurality of tuples comprises one of the plurality of users, one of the plurality of establishments the one user has visited, and one of the plurality of items the one user has ordered at the one establishment; and

 extract the plurality of establishments and the plurality of items from the plurality of tuples.

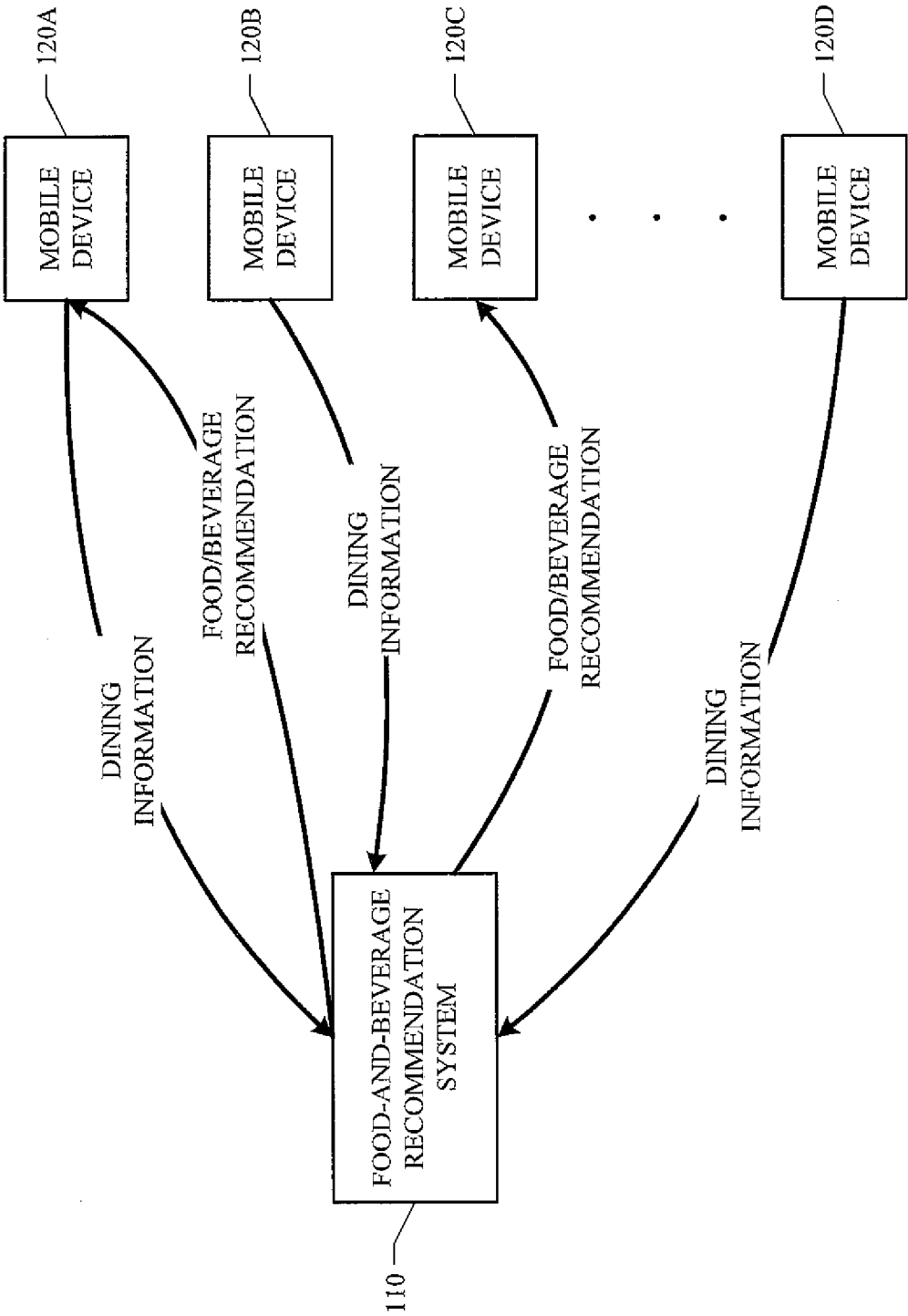


FIGURE 1

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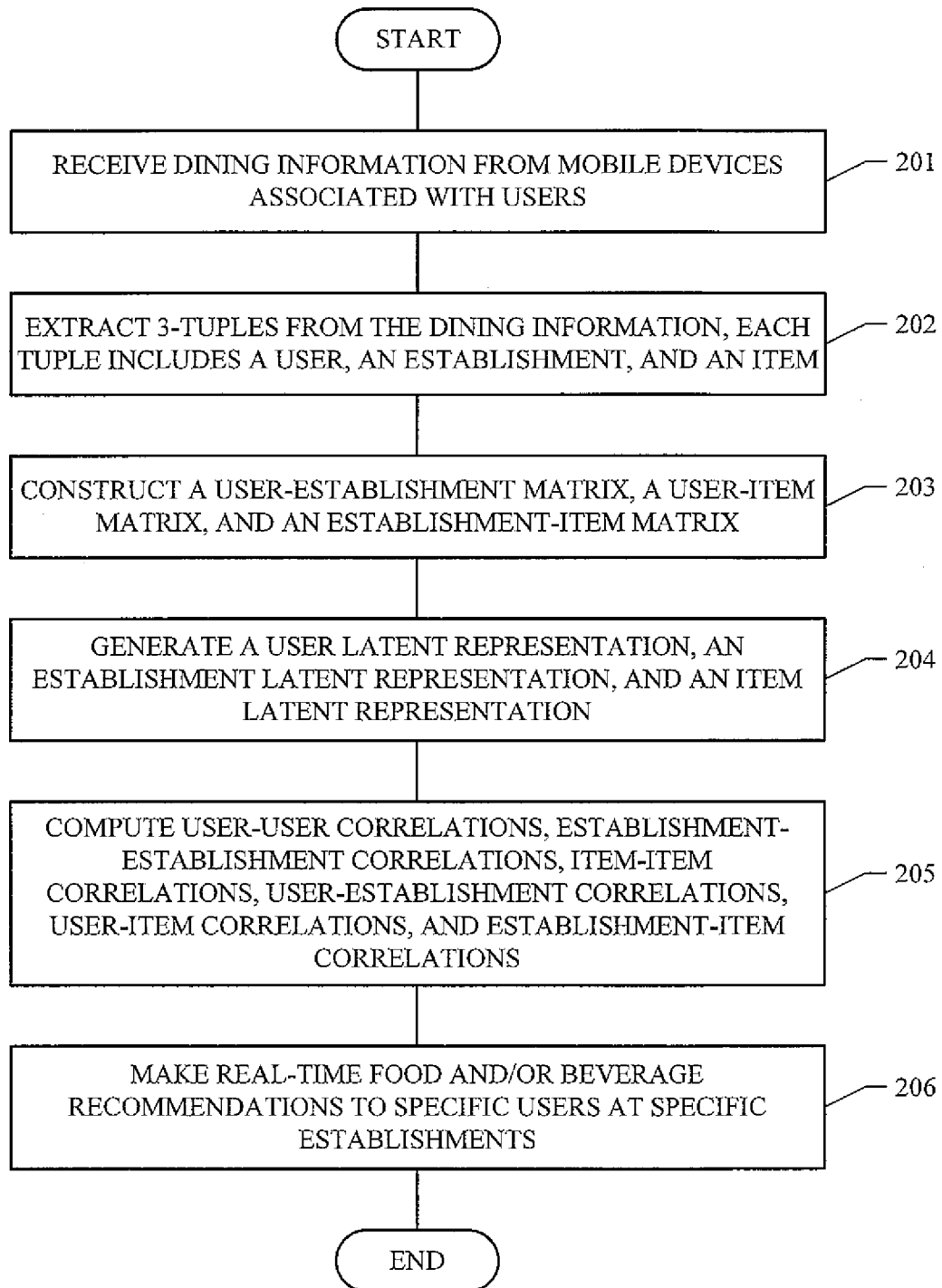


FIGURE 2

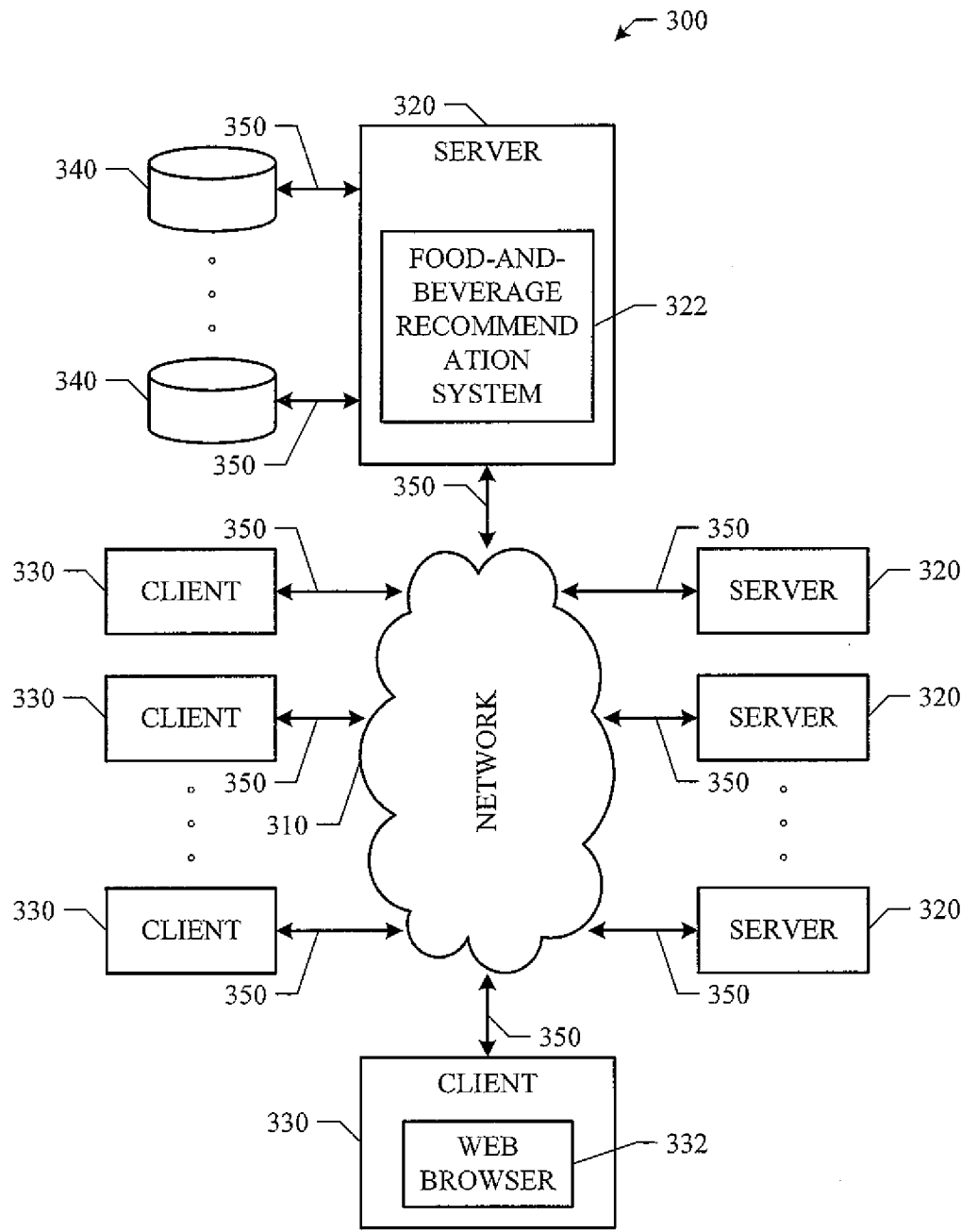


FIGURE 3

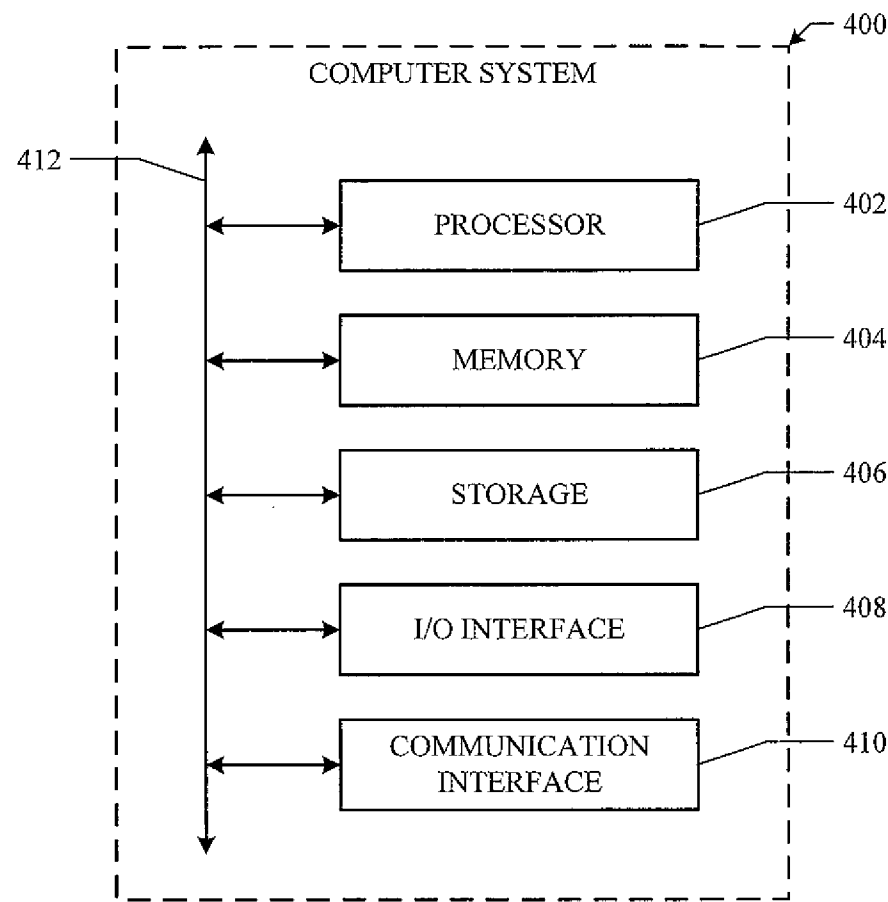


FIGURE 4