

METHOD, DEVICE AND COMPUTER READABLE MEDIUM FOR RENDERING ORGANIC AND PAID CONTENT

TECHNICAL FIELD

[001] The present specification relates broadly, but not exclusively, to methods, devices, and computer readable medium for rendering organic and paid content.

BACKGROUND

[002] Social networking platforms provide to users a mixture of two types of content: organic (also known as natural) contents and paid contents. Organic contents are contents that the social networking system shows to users without direct compensation from a content provider, i.e., an organic content provider. Paid contents usually include advertisements that are only shown as advertisers pay the social networking system. The advertisers are also referred to as paid content providers.

[003] For example, when a social network system is a food delivery platform (for example, GrabFood) and a user browses food delivery page in search of certain food, the food delivery platform may return a recommended merchant list in response to the user's action of browsing. The recommended merchant list may include both food merchants (i.e. organic content providers) and ads merchants (i.e. paid content providers).

[004] When organic and paid contents are rendered together in a recommended merchant list, the ranking of the organic and paid contents in the list faces complex objectives, sometimes with conflict of interests. On one hand, the social networking system may have an objective to improve search efficiency for a better user experience. In this regard, food merchants that the user previously ordered food from should be shown at top positions in the recommended merchant list, so that the eater can find a most relevant merchant in an efficient manner and check out in a short time. On the other hand, the social networking system may have another objective for users to be more interactive and have more engagement with the ads merchants, so as to avoid inventory shortage issues for ad services on the social networking system (Otherwise, there is not enough views for ads to serve).

[005] Conventional techniques for rendering organic and paid contents often rank paid contents at fixed positions of the recommended merchant list, with a tag indicative of advertisement. However, such an approach does not optimize complex objectives that addresses conflict of interests as mentioned above.

[006] A need therefore exists to provide methods and devices that seek to overcome or at least minimize the above-mentioned problems so as to provide an enhanced content rendering with optimized objectives.

SUMMARY

[007] According to an embodiment, there is provided a method for rendering organic and paid content. The method comprises: receiving a request for content from a user of a social networking system; in response to the request, determining one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and ranking the one or more organic content providers and the one or more paid content providers together, the ranking comprising: ranking revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider; optimizing weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization; computing final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and re-ranking an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

[008] According to another embodiment, there is provided a device for rendering organic and paid content. The device comprises: at least one processor; and a memory including computer program code for execution by the at least one processor, the computer program code instructs the at least one processor to: receive a request for content from a user of a social networking system; in response to the request, determine one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and rank the one or more organic content providers and the one or more paid content providers together, the ranking comprising: rank revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is

associated with one or more features of the corresponding paid content provider, optimize weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization; compute final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and re-rank an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

[009] According to yet another embodiment, there is provided a non-transitory computer readable storage medium having instructions encoded thereon that, when executed by a processor, cause the processor to: receive a request for content from a user of a social networking system; in response to the request, determine one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and rank the one or more organic content providers and the one or more paid content providers together, the ranking comprising: rank revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider, optimize weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization; compute final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and re-rank an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Embodiments and implementations are provided by way of example only, and will be better understood and readily apparent to one of ordinary skill in the art from the following written description, read in conjunction with the drawings, in which:

[0011] Figure 1 is a schematic diagram of a device 100 for rendering organic and paid content, according to an embodiment. In this embodiment, the device 100 includes a

content provider determination device 102, a feature score ranking device 104, and an objective optimization device 106. In this embodiment, the objective optimization device 104 includes a feature weight optimization device 108 and a revenue score calculation and re-ranking device 110.

[0012] Figure 2 is a schematic diagram of a device 200 for rendering organic and paid content, according to another embodiment.

[0013] Figure 3 is a flow chart illustrating a method 300 for rendering organic and paid content, according to an embodiment.

[0014] Figure 4 shows a diagram 400 depicting an embodiment of the device 100, which includes an embodiment 402 of content provider determination device, an embodiment 404 of feature score ranking device, and an embodiment 406 of objective optimization device. In this embodiment, the feature score ranking device 404 is a ranking device implemented on a Skywalker platform.

[0015] Figure 5 shows a diagram 500 depicting an embodiment of a portion of the device 100. The depicted portion 500 includes a portion of an embodiment 504 of feature score ranking device and an embodiment 506 of objective optimization device. In this embodiment, the objective optimization device 506 is a complex objective optimizer implemented on a Skywalker platform.

[0016] Figure 6 shows a block diagram of a computer system 600 suitable for use as a device 100 for rendering organic and paid content as exemplified in Figure 1.

[0017] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the dimensions of some of the elements in the illustrations, block diagrams or flowcharts may be exaggerated in respect to other elements to help to improve understanding of the present embodiments.

DETAILED DESCRIPTION

[0018] Embodiments will be described, by way of example only, with reference to the drawings. Like reference numerals and characters in the drawings refer to like elements or equivalents.

[0019] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a

computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0020] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “receiving”, “determining”, “ranking”, “optimizing”, “computing”, “re-ranking” or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0021] The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a computer suitable for executing the various methods / processes described herein will appear from the description below.

[0022] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the specification contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0023] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer

readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a computer effectively results in an apparatus that implements the steps of the preferred method.

[0024] This specification uses the term “configured to” in connection with systems, devices, and computer program components. For a system of one or more computers to be configured to perform particular operations or actions means that the system has installed on it software, firmware, hardware, or a combination of them that in operation cause the system to perform the operations or actions. For one or more computer programs to be configured to perform particular operations or actions means that the one or more programs include instructions that, when executed by data processing apparatus, cause the apparatus to perform the operations or actions. For special-purpose logic circuitry to be configured to perform particular operations or actions means that the circuitry has electronic logic that performs the operations or actions.

[0025] Embodiments of the present application provide approaches that optimize complex objectives to provide an enhanced content rendering technique on a social networking system.

[0026] Figure 1 illustrates a schematic diagram of a device 100 for rendering organic and paid content, according to an embodiment. In this embodiment, the device 100 includes a content provider determination device 102, a feature score ranking device 104, and an objective optimization device 106. In this embodiment, the objective optimization device 106 includes a feature weight optimization device 108 and a revenue score calculation and re-ranking device 110. The device 100, the content provider determination device 102, the feature score ranking device 104 and the objective optimization device 106 may comprise other modules or components that are not depicted in Figure 1 for the sake of simplicity.

[0027] The content provider determination device 102, the feature score ranking device 104, and the objective optimization device 106 are configured to cause the device 100 to perform the steps for rendering organic and paid content as described in the present application. Details of the steps will be described below with reference to Figure 3, which depicts a flow chart illustrating a method 300 for rendering organic and paid content according to an embodiment.

[0028] At step 302, the device 100 is configured to receive a request for content from a user of a social networking system. The device 100 can be a server that is a component of a social networking system (not depicted) or a third-party server that provides services to the social networking system. For example, the request for content can be sent from the user's device 101 when the user browses food delivery page on the social networking system. In another example, the request for content can be sent from the user's device 101 in the form of a keyword search on the food delivery page for a certain type of food (e.g., ice cream). It is appreciable to those skilled in the art that the request for content can be in other possible forms. The request can be received directly at the content provider determination device 102 in the device 100, or received at a receiver module (not depicted for the sake of simplicity) in the device 100 and then transmitted to the content provider determination device 102 for processing.

[0029] At step 304, in response to the request, the content provider determination device 102 determines one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system. In some embodiments, the one or more organic content providers include food merchants. The paid content providers include ads merchants.

[0030] The determination 304 of the one or more organic content providers and one or more paid content providers will be described below with reference to Figure 4, which depicts an embodiment 402 of content provider determination device, an embodiment 404 of feature score ranking device, and an embodiment 406 of objective optimization device. In this embodiment, the feature score ranking device 404 is a ranking device implemented on a Skywalker platform.

[0031] In the embodiment shown in Figure 4, the content provider determination device 402 includes a pax-api module 408, a food-mlt module 410, a food-search module 412 and an ads-server module 414, which are backend service servers of the social networking system. For example, the pax-api module 408 is a backend gateway service server for Deliveries Commerce Workstream, the food-mlt module 410 is a backend service server related to recommendation, the food-search module 412 is a backend service server related to search, and the ads-server module 414 is a backend service server related to advertisement.

[0032] In some embodiments, the determination 304 of the one or more organic content providers and one or more paid content providers includes sub-steps 304a and 304b. In sub-

step 304a, the pax-api module 408 sends the user's information to one or more backend service servers. The user's information is referred to as "pax info" in the present application, which includes the user's account name and the user's historical data on the social networking system. The user's historical data includes the user's browsing history and the user's food order history on the social networking system. The pax info may also include the user's geolocation data, such as latitude, longitude, city, etc of the user's location.

[0033] The sub-step 304a may include one or more sub-steps 304a₁, 304a₂, 304a₃, ... 304a_n which can be performed simultaneously or in sequential order. As shown in Figure 4, in response to the request received at step 302, the pax-api module 408 of the content provider determination device 402 is triggered to send the user's information to the food-mlt module 410 at sub-step 304a₁, to the food-search module 412 at sub-step 304a₂, and to the ads-server module 414 at sub-step 304a₃ to determine one or more organic content providers and one or more paid content providers to be rendered to the user.

[0034] In the present embodiment, the pax info is sent to three backend service servers, i.e. the food-mlt module 410, the food-search module 412 and the ads-server module 414, for a broad selection of organic content providers and paid content providers. It is appreciable to those skilled in the art that, the number of backend service servers that receive the pax info from the pax-api module 408 can be modified based on practical needs and requirements, and the number of sub-steps in the sub-step 304a will change accordingly. It is also understandable that in addition to or other than the three backend service servers 410, 412 and 414 depicted in Figure 4, there may be other backend service servers that can be used for sub-steps 304a and 304b.

[0035] In sub-step 304b, the one or more backend service servers determine one or more organic content providers and one or more paid content providers based on the user's historical data on the social networking system. Corresponding to the sub-step 304a, the sub-step 304b may also include one or more sub-steps 304b₁, 304b₂, 304b₃, ... 304b_n which can be performed simultaneously or in sequential order. As shown in Figure 4, the food-mlt module 410, the food-search module 412, and the ads-server module 414 determine one or more organic content providers and one or more paid content providers respectively at sub-steps 304b₁, 304b₂, 304b₃ based on the user's historical data on the social networking system. The one or more organic content providers and one or more paid content providers are then provided to the feature score ranking device 404, which is in turn coupled to the objective optimization device 406, to be ranked together at step 306 with optimized objectives in accordance with embodiments of the present application to provide an enhanced content rendering. In some embodiments, the food-mlt module 410 may provide one or more organic

content providers together with the pax info to the feature score ranking device 404 via a Personalization DS team platform. The food-search module 412 may provide one or more organic content providers together with the pax info to the feature score ranking device 404 via an Elastic Search platform. the ads-server module 414 may provide one or more paid content providers together with the pax info to the feature score ranking device 404 via an ads-server of the social networking system.

[0036] In the present embodiment, main objectives to achieve for the social networking system include organic content revenue (e.g. revenue from organic content providers, e.g. food merchants providing food and delivery) and paid content revenue (e.g. revenue from paid content providers, e.g. ads merchants). The present application provides two approaches to optimize the two objectives: single objective optimization and multi-objective optimization. In the single objective optimization, organic content revenue and paid content revenue are combined as a single objective and assigned with a weight denoting the single objective's importance. In the multi-objective optimization, the organic content revenue and the paid content revenue are treated as two separate objectives that both need to be optimized at the same time, and each objective is assigned with a weight denoting the corresponding importance.

[0037] In the present embodiment, certain features of organic content providers and paid content providers on the social networking system are indicative of their revenues. These features include predicted conversion rate (pCVR) and predicted click-through rate (pCTR). pCVR is a probabilistic score indicative of a predicted number of transactions an organic content provider or a paid content provider can receive during a specific period (a month, a year, duration of a campaign, etc) divided by the total number of users that browsed the organic content provider's or the paid content provider page during the specific period. pCTR is a probabilistic score indicative of how often users who see a paid content provider or an organic content provider in the recommended merchant list end up clicking it. It is appreciable to those skilled in the art that the features of organic content providers and paid content providers may include other rates that are indicative of revenues.

[0038] Since the above-mentioned features (e.g. pCVR, pCTR, etc) are universal across the social networking system, revenue of each of the one or more organic content providers and the one or more paid content providers determined in step 304 can thus be quantified by a revenue score that is associated with one or more features of the corresponding organic or paid content provider. The content providers with highest revenue scores can thus be rendered at top positions in the recommended merchant list.

To achieve this, the one or more organic content providers and the one or more paid content providers are ranked together by the objective optimization device 106 at step 306.

[0039] The ranking step 306 includes sub-steps 306a, 306b, 306c and 306d. These sub-steps are not depicted for the sake of simplicity. At sub-step 306a, revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers are ranked at the revenue score calculation and re-ranking device 110 of the objective optimization device 106. The revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider. The revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider.

[0040] In some embodiments, prior to the ranking of revenue scores in sub-step 306a, revenue score of each of the one or more organic content providers and the one or more paid content providers is calculated at the revenue score calculation and re-ranking device 110 of the objective optimization device 106. To calculate the revenue score, each of the one or more features can be ranked across the one or more organic content providers and the one or more paid content providers in step 305 at the feature score ranking device 104. An embodiment 404 of the feature score ranking device 104 is depicted in Figure 4. In Figure 4, the feature score ranking device 404 comprises a Skywalker module 416, a Skywalker UPS - CVR module 418 and a Skywalker UPS - Ads CTR module 420. In this embodiment, the step 305 includes sub-steps 305a₁, 305a₂, 305b₁, and 305b₂. Upon receipt of the one or more organic content providers and the one or more paid content providers, the Skywalker module 416 merges information of all the one or more organic content providers and the one or more paid content providers together and sends it to the Skywalker UPS - CVR module 418 at sub-step 305a₁ for ranking the feature pCVR for all the one or more organic content providers and the one or more paid content providers and to Skywalker UPS - Ads CTR module 420 at sub-step 305a₂ for ranking the feature pCTR for all the one or more organic content providers and the one or more paid content providers. In response, the Skywalker UPS - CVR module 418 produces pCVR scores for the one or more organic content providers and the one or more paid content providers and sends them together at sub-step 305b₁ with information of the one or more organic content providers and the one or more paid content providers to the objective optimization device 106. Similarly, Skywalker complex objective optimizer. the Skywalker UPS - CTR module 420 produces pCTR scores for the one or more organic content providers and the one or more paid content providers and sends them together at sub-step 305b₂ with information of the one or more organic content

providers and the one or more paid content providers to the objective optimization device 106. The feature scores, i.e. pCVR scores and pCTR scores, for the one or more organic content providers and the one or more paid content providers can be used in calculation of the revenue score of each of the one or more organic content providers and the one or more paid content providers.

[0041] To achieve optimized objectives, each of the one or more features of the one or more organic content providers and the one or more paid content providers is assigned with a weight denoting its importance in a content rendering process. Such a weight can be generated at a component of the objective optimization device 106. For example, a personalization DS airflow platform 522 in an embodiment 506 of the objective optimization device as depicted in Figure 5.

[0042] The weights of the one or more features can be optimized in different optimization cycles for a desired result. At sub-step 306b, weights of the one or more features of the one or more organic content providers and the one or more paid content providers are optimized based on a single objective optimization or a multi-objective optimization. In some embodiments, the weights of the one or more features of the one or more organic content providers and the one or more paid content providers are optimized at the feature weight optimization device 108 of the objective optimization device 106.

[0043] As described above, the single objective optimization and the multi-objective optimization as provided in the present application optimize complex objectives for the social networking system and advantageously achieve an optimized recommended merchant list where organic product providers and paid product providers with highest revenue scores are ranked at top positions on the list for rendering to the user. In the present application, as the revenue scores are associated with pCVR and pCTR features of the one or more organic product providers and paid product providers, the organic product providers and paid product providers ranked at top positions by the present application are more relevant to users, more attractive for users to click, and more conducive to successful transactions. An enhanced rendering of organic and paid content is thus achieved.

[0044] For single objective optimization, the objective is a weighted average of organic content revenue and paid content revenue as described above. Parameters that need to be optimized is the weights of the one or more features of the one or more organic content providers and the one or more paid content providers.

[0045] To achieve the single objective optimization, the present application uses a black-box optimization, for example Bayesian optimization with Gaussian process, to find a maximum objective by tuning the weights of the one or more features based on historical data of the one or more organic content providers and the one or more paid content providers, e.g. weight and objective pairs $(\omega, x\text{-objective})$. In an embodiment of single objective optimization, the weights of the one or more features of the one or more organic content providers and the one or more paid content providers are optimized in accordance with the following equation (1).

[0046] Equation (1):

$$\begin{aligned} & \max_w (a * R_{food} + (1 - a) * R_{ads}) \\ & \text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n \text{ for } n \in 1 \dots N \end{aligned}$$

[0047] In the above equation (1), R_{food} is a sum of revenue scores of the one or more organic content providers, wherein the one or more organic content providers are one or more food merchants. R_{ads} is a sum of revenue scores for the one or more paid content providers, wherein the one or more paid content providers are one or more ads merchants. a is a weight for the sum of revenue scores of the one or more organic content providers. x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores. ω_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores. s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

[0048] For multi-objective optimization, both organic content revenue and paid content revenue are considered as objectives to be optimized at the same time. Instead of using the normal acquisition function in the Gaussian process, the present application uses a q-Expected Hypervolume Improvement acquisition function (qEHVI). To maximize qEHVI, the sample average approximation (SAA) approach is used with high-order optimizers for a faster convergence rate, which can finally find the pareto front. A suitable point can thus be chosen on the pareto front with desired organic content revenue and paid content revenue.

[0049] In an embodiment of multi-objective optimization, the weights of the one or more features of the one or more organic content providers and the one or more paid content providers are optimized in accordance with the following equation (2).

[0050] Equation (2):

$$\begin{aligned} & \max_w R_{food} \text{ and } \max_w R_{ads} \\ & \text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n \text{ for } n \in 1 \dots N \end{aligned}$$

[0051] In the above equation (2), R_{food} is a revenue score for one of the one or more organic content providers, wherein the organic content provider is a food merchant. R_{ads} is a revenue score for one of the one or more paid content providers, wherein the paid content provider is an ads merchant. x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores. w_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores. s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

[0052] In the embodiments of single-objective optimization and multi-objective optimization, the weight w_{ni} of the i th feature of the organic content provider or paid content provider in the above-described embodiments can be generated at the personalization DS airflow platform 522, as mentioned above.

[0053] The optimized weights of the features of the one or more organic content providers and the one or more paid content providers are then provided to the revenue score calculation and re-ranking device 110 of the objective optimization device 106. At sub-step 306c, the revenue score calculation and re-ranking device 110 computes final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers.

[0054] At sub-step 306d, the revenue score calculation and re-ranking device 110 re-ranks an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

[0055] In some embodiments, after sub-step 306d, the revenue score calculation and re-ranking device 110 or other components of the device 100 selects a list of organic content providers and paid content providers for presentation to the user based on the re-ranking. The list of organic content providers and paid content providers for presentation to the user include those ranked at top 1 to top n positions in the re-ranking. The number n can be determined based on the practical requirements, e.g., 10, 20, or any other numbers.

[0056] Figure 2 illustrates a schematic diagram of a device 200 for rendering organic and paid content according to an embodiment. The device 200 at least includes one or more processor 202 and a memory 204. The at least one processor 202 and the memory 204 are interconnected. The memory 204 includes computer program code (not shown in Figure 2) for execution by the at least one processor 202. The computer program code instructs the at least one processor 202 to perform the steps for rendering organic and paid content as shown in Figure 3 and described in the present application.

[0057] At step 302, the computer program code instructs the at least one processor 202 to receive a request for content from a user of a social networking system.

[0058] Thereafter, at step 304, the computer program code instructs the at least one processor 202 to, in response to the request, determine one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system.

[0059] Thereafter, at step 306, the computer program code instructs the at least one processor 202 to rearrange the plurality of images in accordance with a pre-determined order of colours.

[0060] Subsequently, at step 308, the computer program code instructs the at least one processor 202 to rank the one or more organic content providers and the one or more paid content providers together. The ranking comprises: ranking revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider; optimizing weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization; computing final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and re-ranking an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

[0061] Figures 3 and 4 have been described with reference to Figure 1 in the preceding description. Figure 5 shows a diagram 500 depicting an embodiment of a portion of the

device 100. The depicted portion 500 includes a portion of an embodiment 504 of feature score ranking device including a UPS - CVR module 518 and a Skywalker UPS - Ads CTR module 520 as described above and an embodiment 506 of objective optimization device. In this embodiment, the objective optimization device 506 is a complex objective optimizer implemented on a Skywalker platform.

[0062] In the embodiment of Figure 5, the objective optimization device 506 includes a catwalk orchestrator 528 which is an embodiment of the revenue score calculation and re-ranking device 110 as shown in Figure 1, and a personalization DS airflow module 522 which is an embodiment of the feature weight optimization device 108 as shown in Figure 1.

[0063] As shown in Figure 5, when the request for content is a real-time request for content from a user, the catwalk orchestrator 528 receives real-time feature scores for one or more features (e.g. pCVR scores, pCTR scores, etc) of the one or more organic content providers and the one or more paid content providers, from the Skywalker UPS - CVR module 518 at step 505b₁ and the Skywalker UPS - Ads CTR module 520 at step 505b₂. Additionally, the catwalk orchestrator 528 can also receive offline features from an amphawa offline feature module 526 for a more comprehensive optimization. The offline features include popularity, average order value, rating, etc of the one or more organic content providers and the one or more paid content providers, which can be interchangeably referred to as merchant popularity, merchant average order value, merchant rating, etc.

[0064] As shown in Figure 5, the weights of the one or more features (e.g. pCVR scores, pCTR scores, etc) of the one or more organic content providers and the one or more paid content providers are generated by the personalization DS airflow module 522, and optimized therein based on a single objective optimization or a multi-objective optimization as described above with reference to sub-step 306b.

[0065] Thereafter, the personalization DS airflow module 522 transmits, at step 505d₁, the optimized weights of the one or more features (e.g. pCVR scores, pCTR scores, etc) of the one or more organic content providers and the one or more paid content providers to an amphawa feature weights module 524 periodically based on real-time feedback in a form of weight and objective pairs. The amphawa feature weights module 524 subsequently transmits, at step 505d₂, the optimized weights of the one or more features (e.g. pCVR scores, pCTR scores, etc) of the one or more organic content providers and the one or more paid content providers to the catwalk orchestrator 528.

[0066] Thereafter, the catwalk orchestrator 528 computes final revenue scores for the one or more organic content providers and the one or more paid content providers based on the optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers, and re-ranks an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores as described above with reference to sub-steps 306c and 306d.

[0067] In some embodiments, the catwalk orchestrator 528 may apply different optimized weights based on the user's group for the computing of the final revenue scores. For example, users in a treatment group have different optimized weights of the one or more features (e.g. pCVR scores, pCTR scores, etc) compared with users in a control group. For example, in an embodiment where the catwalk orchestrator 528 uses the single objective optimization according to the above described Equation (1), the final revenue score for each user in a control group can be represented by Formula (1), and the final revenue score for each user in a treatment group can be represented by Formula (2).

Formula (1): final revenue score of a user in a control group = $0.5 * \text{pCVR score of the user} + 0.5 * \text{pCTR score of the user}$.

Formula (2): final revenue score of a user in a treatment group = $0.3 * \text{pCVR score of the user} + 0.7 * \text{pCTR score of the user}$.

[0068] The information of the user's group is stored in a GrabX module 530 and transmitted to the objective optimization device 506 in step 505e for the above computing of the final revenue scores. In the embodiment shown in Figure 5, the GrabX module 530 is an external component that communicates with the objective optimization device 506. It is appreciable to those skilled in the art that the GrabX module 530 may be an internal component of the objective optimization device 506 in other embodiments.

[0069] Figure 6 shows a block diagram of a computer system 600 suitable for use as a device 100 for rendering organic and paid content as exemplified in Figure 1.

[0070] The following description of the computer system / computing device 600 is provided by way of example only and is not intended to be limiting.

[0071] As shown in Figure 6, the example computing device 600 includes a processor 604 for executing software routines. Although a single processor is shown for the sake of clarity, the computing device 600 may also include a multi-processor system. The processor 604 is connected to a communication infrastructure 606 for communication with other components

of the computing device 600. The communication infrastructure 606 may include, for example, a communications bus, cross-bar, or network.

[0072] The computing device 600 further includes a main memory 608, such as a random access memory (RAM), and a secondary memory 610. The secondary memory 610 may include, for example, a hard disk drive 612 and/or a removable storage drive 614, which may include a magnetic tape drive, an optical disk drive, or the like. The removable storage drive 614 reads from and/or writes to a removable storage unit 618 in a well-known manner. The removable storage unit 618 may include a magnetic tape, optical disk, or the like, which is read by and written to by removable storage drive 614. As will be appreciated by persons skilled in the relevant art(s), the removable storage unit 618 includes a computer readable storage medium having stored therein computer executable program code instructions and/or data.

[0073] In an alternative implementation, the secondary memory 610 may additionally or alternatively include other similar means for allowing computer programs or other instructions to be loaded into the computing device 600. Such means can include, for example, a removable storage unit 622 and an interface 620. Examples of a removable storage unit 622 and interface 620 include a removable memory chip (such as an EPROM or PROM) and associated socket, and other removable storage units 622 and interfaces 620 which allow software and data to be transferred from the removable storage unit 622 to the computer system 600.

[0074] The computing device 600 also includes at least one communication interface 624. The communication interface 624 allows software and data to be transferred between computing device 600 and external devices via a communication path 626. In various embodiments, the communication interface 624 permits data to be transferred between the computing device 600 and a data communication network, such as a public data or private data communication network. The communication interface 624 may be used to exchange data between different computing devices 600 which such computing devices 600 form part an interconnected computer network. Examples of a communication interface 624 can include a modem, a network interface (such as an Ethernet card), a communication port, an antenna with associated circuitry and the like. The communication interface 624 may be wired or may be wireless. Software and data transferred via the communication interface 624 are in the form of signals which can be electronic, electromagnetic, optical or other signals capable of being received by communication interface 624. These signals are provided to the communication interface via the communication path 626.

[0075] Optionally, the computing device 600 further includes a display interface 602 which performs operations for rendering images to an associated display 630 and an audio interface 632 for performing operations for playing audio content via associated speaker(s) 634.

[0076] As used herein, the term "computer program product" may refer, in part, to removable storage unit 618, removable storage unit 622, a hard disk installed in hard disk drive 612, or a carrier wave carrying software over communication path 626 (wireless link or cable) to communication interface 624. Computer readable storage media refers to any non-transitory tangible storage medium that provides recorded instructions and/or data to the computing device 600 for execution and/or processing. Examples of such storage media include floppy disks, magnetic tape, CD-ROM, DVD, Blu-ray™ Disc, a hard disk drive, a ROM or integrated circuit, USB memory, a magneto-optical disk, or a computer readable card such as a PCMCIA card and the like, whether or not such devices are internal or external of the computing device 600. Examples of transitory or non-tangible computer readable transmission media that may also participate in the provision of software, application programs, instructions and/or data to the computing device 600 include radio or infra-red transmission channels as well as a network connection to another computer or networked device, and the Internet or Intranets including e-mail transmissions and information recorded on Websites and the like.

[0077] The computer programs (also called computer program code) are stored in main memory 608 and/or secondary memory 610. Computer programs can also be received via the communication interface 624. Such computer programs, when executed, enable the computing device 600 to perform one or more features of embodiments discussed herein. In various embodiments, the computer programs, when executed, enable the processor 604 to perform features of the above-described embodiments. Accordingly, such computer programs represent controllers of the computer system 600.

[0078] Software may be stored in a computer program product and loaded into the computing device 600 using the removable storage drive 614, the hard disk drive 612, or the interface 620. Alternatively, the computer program product may be downloaded to the computer system 600 over the communications path 626. The software, when executed by the processor 604, causes the computing device 600 to perform functions of embodiments described herein.

[0079] It is to be understood that the embodiment of Figure 6 is presented merely by way of example. Therefore, in some embodiments one or more features of the computing device 600 may be omitted. Also, in some embodiments, one or more features of the computing device 600 may be combined together. Additionally, in some embodiments, one or more features of the computing device 600 may be split into one or more component parts.

[0080] The techniques described in this specification produce one or more technical effects. As mentioned above, embodiments of the present application provide approaches that optimize complex objectives to provide an enhanced content rendering technique on a social networking system.

[0081] Furthermore, the single objective optimization and the multi-objective optimization as provided in the present application optimize complex objectives for the social networking system and advantageously achieve an optimized recommended merchant list where organic product providers and paid product providers with highest revenue scores are ranked at top positions on the list for rendering to the user. In the present application, as the revenue scores are associated with pCVR and pCTR features of the one or more organic product providers and paid product providers, the organic product providers and paid product providers ranked at top positions by the present application are more relevant to users, more attractive for users to click, and more conducive to successful transactions. In this manner, the enhanced content rendering as described herein improves both efficiency and effectivity of content rendering.

[0082] It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Claims

1. A method for rendering organic and paid content, the method comprising:

receiving a request for content from a user of a social networking system;

in response to the request, determining one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and

ranking the one or more organic content providers and the one or more paid content providers together, the ranking comprising:

ranking revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider;

optimizing weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization;

computing final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and

re-ranking an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

2. The method according to claim 1, wherein during the optimizing of the weights of features, the single objective optimization includes:

$$\max_w (a * R_{food} + (1 - a) * R_{ads})$$
$$\text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n \text{ for } n \in 1 \dots N,$$

wherein

R_{food} is a sum of revenue scores of the one or more organic content providers, wherein the one or more organic content providers are one or more food merchants,

R_{ads} is a sum of revenue scores for the one or more paid content providers, wherein the one or more paid content providers are one or more ads merchants,

a is a weight for the sum of revenue scores of the one or more organic content providers,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

ω_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

3. The method according to any one of the preceding claims, wherein during the optimizing of the weights of features, the multi-objective optimization includes:

$$\begin{aligned} & \max_w R_{food} \text{ and } \max_w R_{ads} \\ & \text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n \text{ for } n \in 1 \dots N, \end{aligned}$$

wherein

R_{food} is a revenue score for one of the one or more organic content providers, wherein the organic content provider is a food merchant,

R_{ads} is a revenue score for one of the one or more paid content providers, wherein the paid content provider is an ads merchant,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

ω_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

4. The method according to any one of the preceding claims, wherein the features of the each organic content provider or the each paid content provider comprise one or more predicted conversion rate (pCVR) and/or predicted click-through rate (pCTR) of the each organic content provider or the each paid content provider.

5. The method according to claim 2 or claim 3, wherein the weight of the i th feature of the organic content provider or paid content provider is generated at a personalization DS airflow platform.

6. The method according to any one of the preceding claims, further comprising:

selecting a list of organic content providers and paid content providers for presentation to the user based on the re-ranking.

7. A device for rendering organic and paid content, the device comprising:

at least one processor; and

a memory including computer program code for execution by the at least one processor, the computer program code instructs the at least one processor to:

receive a request for content from a user of a social networking system;

in response to the request, determine one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and

rank the one or more organic content providers and the one or more paid content providers together, the ranking comprising:

rank revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider,

optimize weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization;

compute final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and

re-rank an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

8. The device according to claim 7, wherein during the optimizing of the weights of features, the device is configured to perform the single objective optimization according to:

$$\max_w (a * R_{food} + (1 - a) * R_{ads})$$
$$\text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{ni} * x_{ni} = s_n \text{ for } n \in 1 \dots N,$$

wherein

R_{food} is a sum of revenue scores of the one or more organic content providers, wherein the one or more organic content providers are one or more food merchants,

R_{ads} is a sum of revenue scores for the one or more paid content providers, wherein the one or more paid content providers are one or more ads merchants,

a is a weight for the sum of revenue scores of the one or more organic content providers,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

w_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

9. The device according to claim 7 or claim 8, wherein during the optimizing of the weights of features, the device is configured to perform the multi-objective optimization according to:

$$\max_w R_{food} \text{ and } \max_w R_{ads} \\ \text{subject to } w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n \text{ for } n \in 1 \dots N,$$

wherein

R_{food} is a revenue score for one of the one or more organic content providers, wherein the organic content provider is a food merchant,

R_{ads} is a revenue score for one of the one or more paid content providers, wherein the paid content provider is an ads merchant,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

w_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

10. The device according to any one of claims 7 to 9, wherein the features of the each organic content provider or the each paid content provider comprise one or more predicted conversion rate (pCVR) and/or predicted click-through rate (pCTR) of the each organic content provider or the each paid content provider.

11. The device according to claim 8 or claim 9, wherein the weight of the i th feature of the organic content provider or paid content provider is generated at a personalization DS airflow platform.

12. The device according to any one of claims 7 to 11, wherein the device is further configured to:

select a list of organic content providers and paid content providers for presentation to the user based on the re-ranking.

13. A non-transitory computer readable storage medium having instructions encoded thereon that, when executed by a processor, cause the processor to:

receive a request for content from a user of a social networking system;

in response to the request, determine one or more organic content providers and one or more paid content providers for the user based on the user's historical data on the social networking system, and

rank the one or more organic content providers and the one or more paid content providers together, the ranking comprising:

rank revenue scores of the one or more organic content providers and revenue scores of the one or more paid content providers, wherein the revenue score of each of the one or more organic content providers is associated with one or more features of the corresponding organic content provider, and wherein the revenue score of each of the one or more paid content providers is associated with one or more features of the corresponding paid content provider,

optimize weights of features of the one or more organic content providers and features of the one or more paid content providers based on a single objective optimization or a multi-objective optimization;

compute final revenue scores for the one or more organic content providers and the one or more paid content providers based on optimized weights of the features of the one or more organic content providers and the features of the one or more paid content providers; and

re-rank an order of the one or more organic content providers and the one or more paid content providers according to their final revenue scores.

14. The non-transitory computer readable storage medium according to claim 13, further including instructions enclosed thereon that, when during the optimizing of the weights of features, cause the processor to perform the single objective optimization according to:

$$\max_w (a * R_{food} + (1 - a) * R_{ads})$$

$$subject\ to\ w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nl} * x_{nl} = s_n\ for\ n \in 1 \dots N,$$

wherein

R_{food} is a sum of revenue scores of the one or more organic content providers, wherein the one or more organic content providers are one or more food merchants,

R_{ads} is a sum of revenue scores for the one or more paid content providers, wherein the one or more paid content providers are one or more ads merchants,

a is a weight for the sum of revenue scores of the one or more organic content providers,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

w_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

15. The non-transitory computer readable storage medium according to claim 13 or 14, further including instructions enclosed thereon that, when during the optimizing of the weights of features, cause the processor to perform the multi-objective optimization according to:

$$\max_w (a * R_{food} + (1 - a) * R_{ads})$$

subject to $w_{n1} * x_{n1} + w_{n2} * x_{n2} + \dots + w_{nI} * x_{nI} = s_n$ *for* $n \in 1 \dots N$,

wherein

R_{food} is a revenue score for one of the one or more organic content providers, wherein the organic content provider is a food merchant,

R_{ads} is a revenue score for one of the one or more paid content providers, wherein the paid content provider is an ads merchant,

x_{ni} is an i th feature of an organic content provider or a paid content provider ranked at n th position in the ranking of revenue scores,

w_{ni} is a weight of the i th feature of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores, and

s_n is a final revenue score of the organic content provider or paid content provider ranked at n th position in the ranking of revenue scores.

16. The non-transitory computer readable storage medium according to any one of claims 13 to 15, wherein the features of the each organic content provider or the each paid content provider comprise one or more predicted conversion rate (pCVR) and/or predicted click-through rate (pCTR) of the each organic content provider or the each paid content provider.

17. The non-transitory computer readable storage medium according to claim 14 or claim 15, wherein the weight of the i th feature of the organic content provider or paid content provider is generated at a personalization DS airflow platform.

18. The non-transitory computer readable storage medium according to any one of claims 13 to 17, further including instructions enclosed thereon that cause the processor to:

select a list of organic content providers and paid content providers for presentation to the user based on the re-ranking.