

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 200064009 B2**
(10) Patent No. **769761**

(54) Title
Method for optimizing net present value of a cross-selling
marketing campaign

(51)⁶ International Patent Classification(s)
G06F 017/60

(21) Application No: 200064009 (22) Application Date: 2000.08.05

(87) WIPO No: W001/11522

(30) Priority Data

(31) Number (32) Date (33) Country
60/147456 1999.08.06 US

(43) Publication Date : 2001.03.05

(43) Publication Journal Date : 2001.05.10

(44) Accepted Journal Date : 2004.02.05

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(56) Related Art
US 6115693
US 6070142
US 6064973

AU 200064009

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

REVISED VERSION

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 February 2001 (15.02.2001)

PCT

(10) International Publication Number
WO 01/11522 A2

- (51) International Patent Classification: G06F 17/60 (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.
- (21) International Application Number: PCT/US00/21453
- (22) International Filing Date: 5 August 2000 (05.08.2000)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 60/147,456 6 August 1999 (06.08.1999) US
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
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- (48) Date of publication of this revised version: 27 December 2001
- (15) Information about Correction: see PCT Gazette No. 52/2001 of 27 December 2001, Section II
- (74) Agents: ROBERTS, Jon, L. et al.; Roberts Abokhair & Mardula, LLC, Suite 1000, 11800 Sunrise Valley Drive, Reston, VA 20191 (US). For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/11522 A2

(54) Title: METHOD FOR OPTIMIZING NET PRESENT VALUE OF A CROSS-SELLING MARKETING CAMPAIGN

(57) Abstract:

TITLE: Method for Optimizing Net Present Value of a Cross-Selling Marketing Campaign

FIELD OF THE INVENTION

This invention relates generally to the development of a method to optimize the effects of cross-selling marketing campaigns. More specifically, this invention is an improvement on the application of classical methods of discrete linear programming to the problem of multidimensional optimization.

BACKGROUND OF THE INVENTION

Businesses typically have a number of promotions to offer to a large list of prospective customers. Each promotion may have an eligibility condition, a response model, and a profitability model associated with it.

Some promotions may be combined into *Peer Groups* (i.e., groups of mutually exclusive offers, such as a credit card with different interest rates). A constraint may be placed on the maximum number of offers that goes to any customer; in addition, there may be business requirements such as minimal number of sales, minimal NPV (Net Present Value) per customer, maximal budget, etc. These requirements may apply to any individual promotion, a peer group, or a campaign as a whole.

The goal of cross-selling marketing optimization is to determine what offers to send to which customers to maximize a utility function of the campaign (total NPV, total number of sales etc.), while satisfying all the business requirements and constraints.

The present state of the art lets marketers process one offer at a time. A response and/or profitability model is applied and customers are rank-ordered based on propensity to respond to the offer. After this ordering, a certain percentage from the top of the list is selected to receive the offer. The same process is applied to all available offers separately.

As a result, the best, most responsive and valuable customers are saturated with offers and the middle segment of the customer list is ignored. The overall efficiency of the

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campaign therefore degrades.

Another significant drawback of this approach is the inability to satisfy various real-life constraints and business goals.

Most sophisticated marketers have tried to consolidate models built for different
 5 offers. However, these attempts have not been based on any solid scientific method, but rather have utilised an ad hoc approach. Because of this, only the most-simple constraints have been able to be satisfied and the solutions have been sub-optimal with respect to a utility function. In fact, these marketers haven't even been able to estimate how far off they are from the true optimum.

10 What would therefore be useful is a process that provides a mathematically optimal offer allocation, i. e., one that selects an optimal set of offers for each customer that maximises the utility function and satisfies all business goals and constraints.

SUMMARY OF THE INVENTION

15 The present invention represents the application of a novel iterative algorithm to the problem of multidimensional optimisation. The present invention supplies a strict, nonlinear mathematical solution to what has traditionally been treated as a linear multidimensional problem.

The problem in its original form is a problem of discrete linear programming.
 20 However, due to a huge number of dimensions (in a typical business case $N = O(10^8)$, $M = O(10^2)$), the application of classical methods of discrete linear programming is not feasible.

The process of the present invention consists of randomly selecting a statistically significant sample of a prospect list, calculating the value of the utility function for each pair of an offer and selected prospects, reducing the original linear multidimensional
 25 problem to a non-linear problem with a feasible number of dimensions, solving the nonlinear problem for the selected sample numerically with the desired tolerance using an iterative algorithm, and using the results to calculate an optimal set of offers in one pass for the full prospect list.

The present invention seeks to increase the efficiency of a cross-selling marketing
 30 campaign.

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The present invention also seeks to increase the efficiency of cross-selling campaigns that include a large number of offers.

The present invention also seeks to provide optimisation of cross-selling campaigns wherein groups of offers can be mutually exclusive.

5 The present invention also seeks to increase the efficiency of cross-selling campaigns that are targeted to large number of prospective customers.

The present invention also seeks to increase the efficiency of cross-selling campaigns by selecting an individual, optimal set of offers for each customer.

10 The present invention also seeks to constrain of maximum number of offers sent to a customer within cross-selling campaigns.

The present invention also seeks to satisfy business goals, like minimum number of sales and budget constraints, while optimising cross-selling campaigns as applied to individual offers, groups of offers or the entire campaign.

15 The present invention also seeks to maximise a user-chosen utility function, like total NPV or number of sales, within a cross-selling campaign.

The present invention also seeks to mathematically maximise the utility function and satisfy all constraints within a cross-selling campaign.

The present invention also seeks to allow interactive changes in goals or constraints of cross-selling campaigns and quickly view the results.

20 The present invention also seeks to provide final scoring for cross-selling campaigns in a single pass so as to scalable and efficient enough to process a list of 100 million customers overnight.

The present invention also seeks to provide true "one-to-one" marketing in cross-selling campaigns.

25

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart of the basic process of the present invention.

Figure 2 is a more detailed data flow of a marketing optimisation process of the present invention.

present invention.

Figure 3 is a flow chart of the single pass process of the present invention.

Figure 4 is a flow chart of the novel iterative algorithm of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention represents the application of a novel iterative algorithm to the problem of multidimensional optimization of cross-selling campaigns by supplying a strict, nonlinear mathematical solution to the traditional linear multidimensional problem desired to be solved when offering a large number of promotions M to a very large set of prospective customers N .

The process of the present invention, as shown in figure 1, consists of randomly selecting a statistically significant sample 10 of a prospect list, calculating the value of the utility function 20 for each pair of an offer 30 and selected prospects 10, reducing the original *linear* multidimensional problem to a *non-linear* problem 40 with a feasible number of dimensions, solving the non-linear problem 50 for the selected sample numerically with the desired tolerance using an iterative algorithm, and using the results to calculate an optimal set of offers 60 in one pass for the full prospect list.

Let $A=(a_{ij})$, be a *solicitation matrix*, where

$a_{ij} = 1$, if offer j goes to a customer i
 $= 0$, otherwise;

$R = (r_{ij})$, be a *response matrix*, where

r_{ij} - is a probability for a customer i respond to a promotion j ;

$P = (p_{ij})$, be a *profitability matrix*, where

p_{ij} - is a profitability of a customer i , if he/she responds to a promotion j .

Total NPV of the campaign, $NPV = NPV(A, R, P)$, is a linear function of a_{ij} , r_{ij} , p_{ij} and other economic parameters of the campaign.

Eligibility conditions, peer group logic, and maximal number of offers per customer constraint can be expressed by a set of inequalities C_{ik}

$$C_{ik}(A) \leq 0, \quad i = 1, 2, \dots, N, \quad k = 1, 2, \dots, K$$

where C_i are linear functions, and N is of the order of number of customers in the prospect list, K is number of restrictions. These *customer-level restrictions* are applied for each individual. Economic goals are expressed by a set of inequalities G for each promotion and the whole campaign:

$$G_{jl}(A, R, P) \leq 0, \quad j = 1, 2, \dots, M, \quad l = 1, 2, \dots, L_j$$

$$G_0(A, R, P) \leq 0, \quad l = 1, 2, \dots, L_0$$

where G_j are linear functions, and M is of the order of number of promotions in the campaign, L_j is total number of restrictions. These *main* restrictions are applied for a promotion or the campaign, and G is a sum over all eligible customers.

It is desired to then find a solicitation matrix A that maximizes $NPV(A, *)$ under the condition that all constraints C and G are satisfied.

The solution presented by the inventors uses the following steps, as shown in **figure 2**. A first step is to create a campaign or project by selecting a set **202** of targeting optimizer (TO) projects from a modeling database **200**. Each TO project contains promotion and offer economics, and eligibility information for a selected pool of prospects. Each TO project includes substitute offer groups **206**, model calibration **204**, and eligibility information that is combined with the prospect input to create an eligibility matrix **214**.

For prospect input, one selects, randomly, a statistically significant sample or testing DCP (derived customer pool) **212** of a prospect list from a customer database **210**. Matrices P and R are then calculated for selected prospects at **224**. The next steps, to reduce the original *linear* multidimensional problem to a *non-linear* problem with a feasible

number of dimensions and solve the non-linear problem for the selected sample numerically with the desired tolerance using a novel iterative algorithm (described below) is done by the optimization engine 240.

Input data reports 230 record the matrices and offers used. Using this input data, campaign level constraints 242, and offer level constraints 244, the optimization engine 240 produces a solicitation matrix 250. This is used to calculate report data 252 for optimization reports 254 that are tested at 260 to see if the selected constraints 242 and 244 satisfied the desired offer solicitation schema 256. If satisfied, a final report 260 is generated. If the offer solicitation schema 256 are not satisfied, campaign level constraints 242 and offer level constraints 244 are adjusted to produce another iteration.

The optimization engine 240 calculates the vector of parameters L of the *ANPV* (adjusted NPV) functions

$$ANPV_j(L, r_i, p_i),$$

where

$j = 1, 2, \dots, \#$ of promotions;

$r_i = (r_{ij})$ – vector of propensities to respond of a customer i to promotions 1,

2, ...

$p_i = (p_{ij})$ – vector of profitability of a customer i for promotions 1, 2, ...

It then calculates the optimal solicitation matrix 250 in a single pass through the full prospect list. To accomplish that, as shown in figure 3:

1. Read the next customer record 31;
2. Calculate vectors r_i and p_i 32;
3. Calculate $anpv_i = (ANPV_j(L, r_i, p_i), j = 1, 2, \dots, \# \text{ of promotions})$ 33;
4. Based on the values of $anpv_i$ and eligibility conditions, calculate solicitation vector
 $a_i = (a_{ij}, j=1, 2, \dots, \# \text{ of promotions})$, which defines the optimal set of promotions that goes to a customer i at 34; and
5. Repeat the previous four steps until the end of the customer list at 35.

To calculate matrices P and R for selected prospects at 224 and reduce the original *linear* multidimensional problem to a *non-linear* problem with a feasible number of dimensions described above, the present invention needs to solve the high dimensional conditional extremum problem with a large number of restrictions. The present invention uses the Lagrange multiplier technique to take into account *only the main restrictions*. They can be of an equality or inequality type. This low-dimensional nonlinear problem is solved by a gradient type iterative process.

At each iterative step, the optimization of $ANPV_j(L, r_i, p_i)$ under customer-level restrictions (high dimensional linear problem) is made directly, record by record. It is equivalent to the following min-max problem:

$$\text{Min}_{j(L_k > 0, L_c)} \text{Max}_{j(C_k < 0)} ANPV(L, r_i, p_i),$$

$$\text{where } ANPV(L, r_i, p_i) = ANPV(L, r_i, p_i)_0 + L_b G_b(A, R, P) + L_c G_c(A, R, P)$$

Here, summation over all the inequalities is assumed.

The algorithm, as shown in **figure 4**, consists of following steps:

1. Prepare data 41.
2. Calculate initial value of the functional and gradients 42.
3. Set a value for initial algorithm steps 43; for each Lagrange multiplier, the step should be set equal to the initial value of the functional divided by the square of the gradient.
4. Make a step along the gradient 44.
5. Update the step 45, if needed.
6. Calculate new value of the functional 46, taking customer level restrictions into account.
7. Check convergence 47.
8. If not converged at 48, go to step 4.
9. Output the results 49 upon adequate convergence.

It is important to underscore that the above algorithm is *not* a heuristic, but delivers a strict mathematical solution for the multidimensional optimization problem formulated above.

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Tests performed by inventors on a variety of real business cases show that the iterative procedure in Step 4 above typically converges with the tolerance of 0.1 % in less than 30 iterations. That allows a user to work with the cross-selling optimiser of the present invention interactively and perform real-time analysis of the financial outcome of marketing activities.

A novel feature of the algorithm used by the present invention, the one-pass scoring, enables rollout scoring of a 100M record database overnight.

The present invention operates on a computer system and is used for targeted marketing purposes. Using the present invention in conjunction with a neural network, the present invention provides a user with data indicating the individuals or classes or individuals who are most likely to respond to direct marketing.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

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The claims defining the invention are as follows:

1. A computer-implemented method for optimizing a cross-selling marketing campaign that includes $j = 1$ to M promotions, targeting $i = 1$ to N customers, said method
 - 5 calculating an $N \times M$ solicitation matrix $A = (a_{ij})$, where each a_{ij} is to be set to a first value when said specific promotion j is to be offered to said specific customer i , or otherwise is to be set to a second value, and comprising the steps of:
 - (a) accessing a customer database and randomly selecting a statistically significant sample of n customer records from N customer records;
 - 10 (b) calculating an $n \times M$ response matrix $R = (r_{ij})$, where each r_{ij} is the probability that a specific customer i within said n customers will respond to a specific promotion j ;
 - (c) calculating an $n \times M$ profitability matrix $P = (p_{ij})$, where each p_{ij} is the profitability of said specific customer i when they positively respond to said specific
 15 promotion j ;
 - (d) selecting a utility function that is a function of at least said response, profitability and solicitation matrices, said utility function being linear with respect to a_{ij} ;
 - (e) defining a set of $N \times K$ customer constraint inequalities, $C_{ik}(A) \neq 0$, wherein
 20 K is the total number of customer constraints; C_{ik} are linear functions with respect to a_{ij} ; and each of $k = 1$ to K constraints is reflective of a constraint selected from the group consisting of: an eligibility condition constraint, a peer group logic constraint and a maximum number of offers constraint;
 - (f) defining a set of Q economic constraint inequalities, $G_q(A, R, P) \neq 0$, wherein
 25 Q is the total number of economic constraints; G_q are linear functions with respect to a_{ij} ; and each of $q = 1$ to Q constraints is reflective of an economic goal of the cross-selling marketing campaign, and thus formulating an integer optimization problem with $n \times M$ variables;
 - (g) deriving a non-linear problem that is mathematically equivalent to said integer optimization problem having Q dimensions;
 - 30 (h) iteratively solving said non-linear problem on said sample of n customer records within a pre-defined tolerance; and

- 10 -

(i) accessing said customer database and using the solution of the said non-linear problem to calculate each a_{ij} of said $N \times M$ solicitation matrix A, wherein the values set for each a_{ij} within said solicitation matrix A is a solution to said integer optimization problem.

5

2. The method of Claim 1, wherein M is in the order of magnitude of 10^3 .

3. The method of Claim 1, wherein N is in the order of magnitude of 10^8 .

10 4. The method of Claim 1, wherein said first value is 1 and said second value is 0.

5. The method of Claim 1, wherein said pre-defined tolerance is about 0.1%.

15 6. The method of Claim 1, wherein said utility function selected in step (d) is a net present value (NPV) function expressed as: $NPV(A, R, P)$.

7. The method of Claim 6, wherein step (h) is accomplished by formulating a min-max problem using a LaGrange multiplier technique.

20 8. The method of Claim 7, wherein said min-max problem is expressed as:

$$\text{Min}_{j \{L_b > 0, L_e\}} \text{Max}_{j \{C \leq 0\}} \text{ANPV}_j(L, r_i, p_i);$$

wherein $\text{ANPV}(L, r_i, p_i) = \text{NPV}_j(L, r_i, p_i) + L_b G_b(A, R, P) + L_e G_e(A, R, P)$; and

wherein each of L_b is the inequality component of a LaGrange multiplier, and each of L_e is the equality component of said LaGrange multiplier.

25

9. The method of Claim 8, wherein step (h) is accomplished by iteratively solving said min-max problem by performing at least the following steps:

calculating an initial value of said ANPV function and a gradient vector;

setting an initial value;

30

setting each of Q number of LaGrange multipliers to said initial value of said ANPV function divided by the square of said gradient vector;

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- making a step along said gradient vector;
- updating said step size when needed;
- calculating a new value of said ANPV function taking said set of K constraints into account; and
- 5 determining whether there is convergence within said pre-defined tolerance.

- 10. The method of Claim 8, wherein step (i) is accomplished in a single pass through said N customer records by performing the following steps for each of said N customers:
 - reading a customer record i ;
 - 10 calculating vectors r_i and p_i ;
 - calculating $anpv_i = ANPV_j(L, r_i, p_i)$; and
 - using said calculated value of $anpv_i$ and said $k = 1$ to K constraints to calculate said solicitation matrix vector $a_i = (a_{ij})$.

- 15 11. A method for optimizing a cross-selling marketing campaign, substantially as herein disclosed with reference to the figures.

20

DATED this 20th day of October, 2003
MARKETSWITCH COPORATION
 By Their Patent Attorneys
 DAVIES COLLISON CAVE

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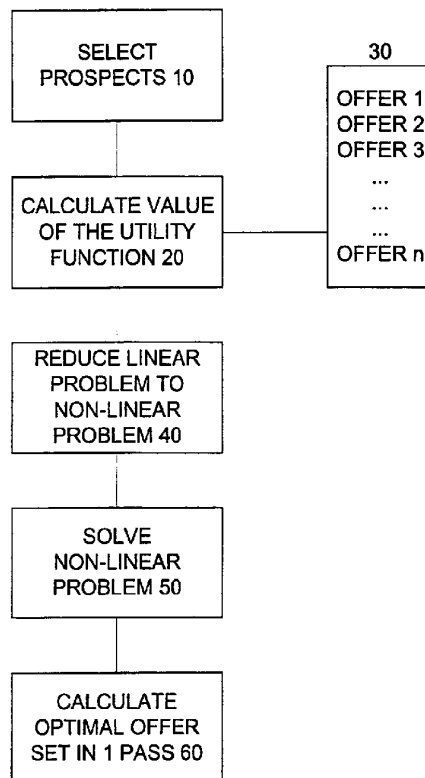


FIGURE 1

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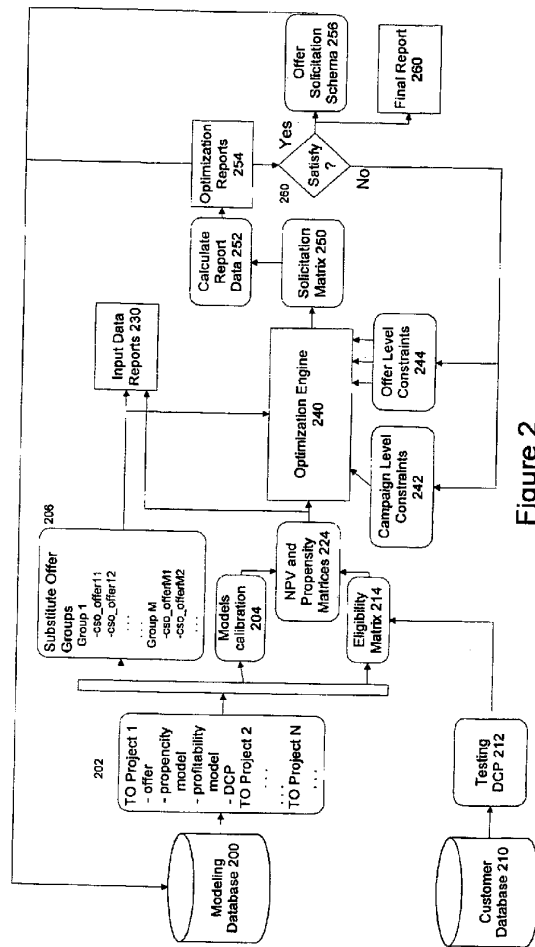


Figure 2

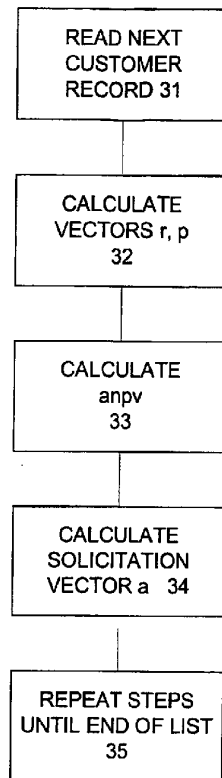


FIGURE 3

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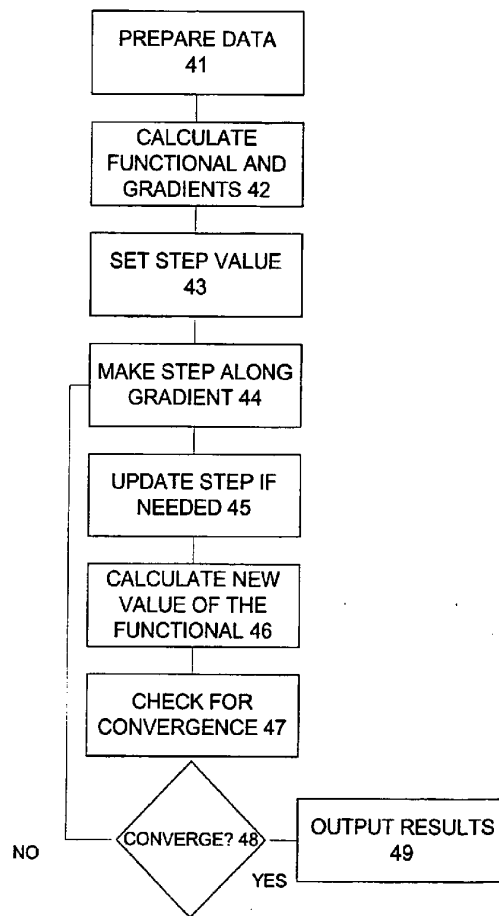


FIGURE 4

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