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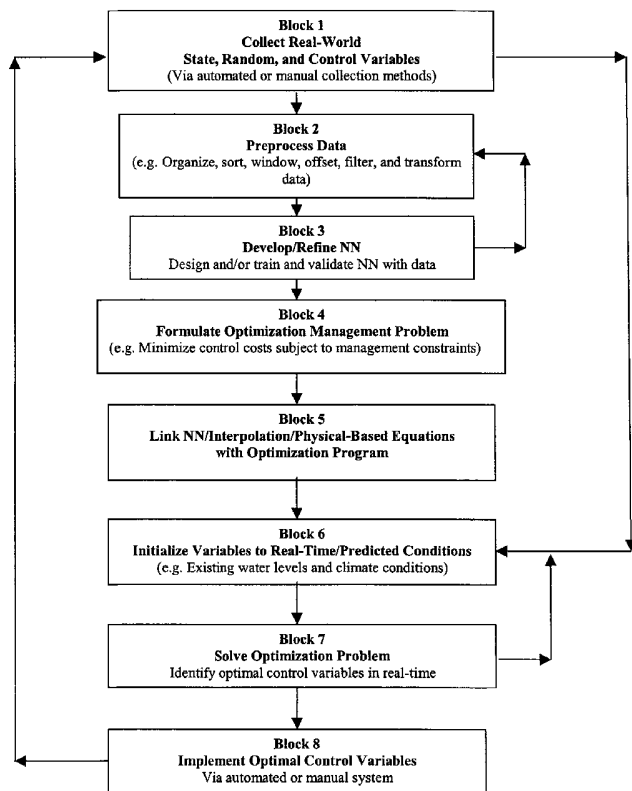
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[Continued on next page]

(54) Title: NEURAL NETWORK BASED PREDICATION AND OPTIMIZATION FOR GROUNDWATER / SURFACE WATER SYSTEM

General Flow Chart for NN Optimization Process  
Applied to Groundwater/Surface Water Management Problems



(57) Abstract: The present invention relates to a method and apparatus, based on the use of a neural network (NN), for (a) predicting important groundwater/surface water output/state variables, (b) optimizing groundwater/surface water control variables, and/or (c) sensitivity analysis, to identify physical relationships between input and output/state variables used to model the groundwater/surface water system or to analyze the performance parameters of the neural network.



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**(88) Date of publication of the international search report:**

4 September 2003

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 02/33910

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 G01V9/02

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01V

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

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

COMPENDEX, INSPEC, EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
|------------|---|-----------------------|
| X          | GUMRAH F ET AL: "Application of Artificial Neural Networks for the prediction of water quality of polluted aquifer"<br>WATER AIR SOIL POLLUT; WATER, AIR AND SOIL POLLUTION 2000 KLUWER ACADEMIC PUBLISHERS, NETHERLANDS,<br>vol. 119, no. 1, 2000, pages 275-294,<br>XP008013691 | 1, 4, 5, 7            |
| A          | page 280 -page 289<br>---<br>-/--   | 3                     |

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

° Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

16 April 2003

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29. 04. 03

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## INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 02/33910

| C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT |  |                       |
|--|--|-----------------------|
| Category °   | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
| X  | <p>STOKELJ T ET AL: "Enhanced water management of cascade hydro system"<br/>           PROCEEDINGS OF THE IASTED INTERNATIONAL CONFERENCE POWER AND ENERGY SYSTEMS, PROCEEDINGS OF 2000 CONFERENCE ON POWER AND ENERGY SYSTEMS (PES 2000), MARABELLA, SPAIN, 19-22 SEPT. 2000,<br/>           pages 431-436, XP008013687<br/>           2000, Anaheim, CA, USA, IASTED/ACTA Press, USA<br/>           ISBN: 0-88986-300-8<br/>           page 432, right-hand column, line 20 - line 43</p> <p style="text-align: center;">---</p>       | 1,2,6,7               |
| X  | <p>SAWYER C S ET AL: "An evaluation of a neural-network method for aquifer hydraulic conductivities estimation"<br/>           INTELLIGENT ENGINEERING SYSTEMS THROUGH ARTIFICIAL NEURAL NETWORKS. VOL.4, PROCEEDINGS INTELLIGENT ENGINEERING SYSTEMS THROUGH ARTIFICIAL NEURAL NETWORKS, ST. LOUIS, MO, USA, 13-16 NOV. 1994,<br/>           pages 1167-1173, XP008013686<br/>           1994, New York, NY, USA, ASME, USA<br/>           page 1169, last paragraph -page 1170, paragraph 4</p> <p style="text-align: center;">---</p> | 1                     |
| X  | <p>JOHNSON VIRGINIA M ET AL: "Location analysis in ground-water remediation using neural networks"<br/>           GROUND WATER;GROUND WATER SEPT-OCT 1995 GROUND WATER PUBLISHING, DUBLIN, OH, USA, vol. 33, no. 5, September 1995 (1995-09), pages 749-758, XP008013695<br/>           page 751, right-hand column<br/>           page 753, left-hand column, paragraph 2 -right-hand column, last paragraph</p> <p style="text-align: center;">-----</p>   | 8-11                  |

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 02/33910

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3.  As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7

Neural network based water prediction system utilising meteorological data

2. Claims: 8-9

Sensitivity analysis for a neural network for a water system

3. Claims: 10-11

Optimisation procedure for a water system utilising a neural network