

Multi-agent System for water pollution using Genetic Algorithm

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Abstract

Multi-agent system is widely used in the real world. It is composed of many agent types which interact with one another through communication. The multi-agent system field is used in many areas as economics, philosophy, logic, ecology, and the social sciences. Genetic Algorithm (GA) will do well in any environment and one of the most powerful methods, with which to quickly create high quality solution to problems. The technique does not ensure an optimal solution to, however, it usually gives good approximation in a reasonable amount of time. GA would be a good algorithm to make decision whether water pollutes or not. Thus, this paper is proposed to make decision whether water pollutes or not using GA and multi-agent system will help the user with autonomous interaction. In this proposed system, water quality attributes, their ranges and limitation, and the diseases and effects cause of each water pollutant defined by the Environmental Protection Agency (EPA) are used.

Keywords: Multi-agent, Diagnosis agent, Intelligent agent, Genetic Algorithm (GA).

1. Introduction

More recently, the people who live in the world suffer from weather changing such as floods, falling acid rain, earthquakes, and so forth. Such rapid environmental changes threat the lives and property of human beings. Pollution such as air pollution, plastic pollution, water pollution is also the danger for human.

People need to be healthy to try to become the highest living standard. To be healthy, water which is one of the fundamental aspects is needed to be clean. People should know the using water does pollute or not and which attributes can cause water pollution.

And, the people should also know the diseases and the risks cause of water pollution and water pollutants. In this proposed system, computer will help the users with more efficient ways. Then, the users can know whether water pollutes or not, which things are water pollutants, and which diseases can be caused.

Multi-agent will also help the autonomous case to pay messages about the water pollution with GA.

2. Background

Multi-agent system contains a number of agents, which interact with one another through communication. The agents are able to act in an environment. Multi-agent systems have only been studied since about 1980, and the field has only gained widespread recognition since then international interest in the field has grown enormously [4].

The ideas of multi-agent systems are not tied to a single application domain, but, like objects before them, seem to find currency in a host of application domains. The multi-agent systems field, can be understood as consisting of two strands of work. The first is concerned with individual agents, while the second is concerned with collections of these agents [4].

The idea of a multi-agent system is very simple. An agent is a computer system that is capable of independent action on behalf of its user or owner. In other word, an agent can figure out for itself what is needs to do in order to satisfy its design objectives, rather than having to do at any given moment [4].

There are many types of agents in multi-agent system.

In this proposed system, intelligent agent and diagnosis agent are intended for the multi-agent system. To make decision, whether water pollutes or not, GA is used. It can give good approximation concerned with the problem.

A variety of computational models based on evolutionary processes have been proposed, and the most popular models are those known as GA. GA attempts to incorporate ideas of natural evolution. Evolutionary techniques can be viewed either as search methods, or as optimization techniques. GA is an optimization technique based on natural evolution and has been applied to a wide variety of problems including search problems, optimization problems, and in many problems in industry, economics, social science and drug design [5].

The objective of the GA is to find an optimal solution to a problem. Of course, since GA is heuristic procedure, it is not guaranteed to the optimum, but experience has shown that it is able to find very good solutions for a wide range of problems.

3. Multi-agent system

Multi-agent systems are composed of multiple computing elements called agents. The multi-agent system contains a number of agents, which interact with one another through communication.

In this system, among the many agents in multi-agent system, only two agents are used. They are:

1. Intelligent agent
2. Diagnosis agent

3.1 Intelligent agent

The research in the area of multi-agent system is concerned with coordinating intelligent behavior among a collection of autonomous (possibly heterogeneous) intelligent agent. The kinds of capabilities that an intelligent agent is expected to have.

(1) **Reactivity:** Intelligent agents are able to perceive their environment, and respond in a timely fashion to changes that occur in it in order to satisfy their design objectives.

(2) **Proactiveness:** Intelligent agents are able to exhibit goal-directed behavior by taking the initiative in order to satisfy their design objectives.

(3) **Social ability:** Intelligent agents are capable of interacting with other agents (and possible humans) in order to satisfy their design objectives [4].

In this proposed system, intelligent agent is used to deal with user by receiving water quality measurements and to send water quality measurements to diagnosis agent.

When intelligent agent receives the message from the diagnosis agent that the measurements are ok, it will execute them by using Genetic Algorithm. After calculating, it will reply the result to user whether water pollutes or not. If pollute, it will reply the resulted pollutant and send it to diagnosis agent to show the diseases.

3.2 Diagnosis agent

With increasing deployment of multi-agent and distributed systems, there is an increasing need for failure diagnosis systems. Model-based diagnosis (MBD) relies on a model of the diagnosed system. MBD is increasingly being applied in distributed and multi-agent systems.

In this proposed system, diagnosis agent is used to contact with intelligent agent that is the user's measurements from intelligent agent are send to diagnosis agent. If the measurements are not in ranges, diagnosis agent will reply the user that the measurements are invalid. If the user's

measurements can be accepted, it will send the water quality measurements to intelligent agent to calculate by using Genetic Algorithm (GA).

After GA had executed by intelligent agent, it will send the resulted pollutant to diagnosis agent. And, diagnosis agent will extract the related diseases from database. Then, it will show the user the related diseases.

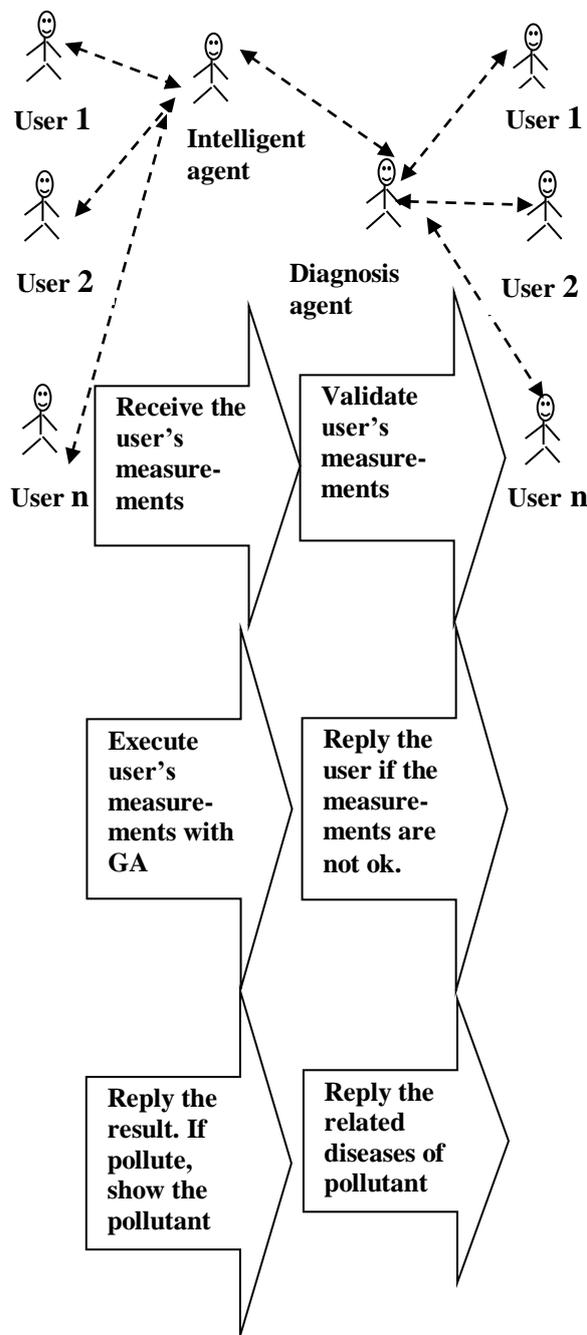


Figure1: Role of Multi-agent system

3.3 Agent role and activities

3.3.1 Role of Intelligent agent and activities

- (1) To receive user's water quality measurements in mg/l.
- (2) To send the water quality measurements to diagnosis agent.
- (3) To receive the message from diagnosis agent whether the measurements are in ranges of water quality.
- (4) To calculate the accepted measurements using Genetic Algorithm.
- (5) To reply whether water pollute or not, if pollute, the resulted pollutant or pollutants.

3.3.2 Role of Diagnosis agent and activities

- (1) To receive the water quality measurements from the intelligent agent.
- (2) To check the input water quality measurements are in ranges of water quality.
- (3) To reply the intelligent agent that the measurements are in range or not.
- (4) To extract the diseases concerned with the resulted pollutant or pollutants from database.
- (5) To show the related diseases of resulted pollutant or pollutants.

4. Genetic Algorithm (GA)

The most popular technique in evolutionary computation research has been the Genetic Algorithm (GA). GA was invented by John Holland.

GA is currently the most prominent and widely used computational models of evolution in artificial-life systems. These centralized models provide a basis for understanding many other systems and phenomena in the world. Researches on GA give illustrative examples in which the genetic algorithm is used to study how learning and evolution interact, and to model ecosystems, immune systems, cognitive systems, and social systems [1].

The origin of Genetic Algorithm which is one of the evolutionary algorithms was an attempt to mimic some of the processes taking place in natural evolution. The comparisons of natural evolution and Genetic Algorithm terminology are as follow [1]:

Table1: Comparison of natural evolution and Genetic Algorithm

Natural evolution	Genetic Algorithm
Chromosome	String
Gene	Feature or character
Allele	Feature value
Locus	String position
Genotype	Binary coded string
Phenotype	A decoded structure

Genes are basic building blocks of a GA. A gene is a binary encoding of a parameter. A chromosome in a computer algorithm is an array of genes. Each chromosome has an associated fitness function assigned to the relative merit. Fitness function is evaluated for each chromosome. Then, GA goes into the production phase, where the parents are chosen by means of a selection process. The selected parents reproduce using GA operator called crossover. In crossover, random points are selected [2].

When the new generation is complete, the process of crossover is stopped. According to the probability of mutation, the chromosomes are chosen at random and any one bit chosen at random is flipped from 0 or 1 or vice versa. After the mutation has taken place, the fitness is evaluated. After a while, all the chromosomes and associated fitness become same. At this point, the GA has to be stopped. According to the results, whether water pollutes or not and which things can cause the water polluting are decided.

In this proposed system, the objective of using GA is to make decision and which things can also be polluted because of the current pollutants, eg; water is polluting caused of Arsenic and other water qualities such as lead, mercury can also be caused water to pollute or not.

GA is not guaranteed to find the global optimum solution to a problem; they are satisfied with finding "acceptably good" solutions to the problem.

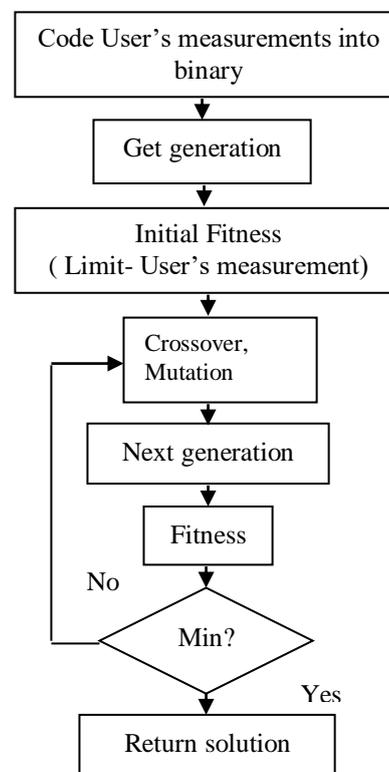


Figure2: Genetic Algorithm Flow Chart

5. Water quality attributes, their limitation and ranges

Clean water and enough of it- is essential to any and all life, animals, plants, and microbes. Human enjoy being around water, but, if water is not clean, it can cause the water borne diseases. So, people should know whether the used water pollutes or not [3].

In this proposed system, twenty attributes of water quality measurements in mg/l can be executed. There are limitations that is water must be polluted over them. And, there are ranges of water quality attributes that must dissolve in water.

Table2: Water quality attributes their limitations and ranges

No	Pollutants	Limit (mg/l)	Range (mg/l)
1	Arsenic	0.05	<0.5
2	Barium	1	0.5 to 1
3	Cadmium	0.01	0.001 to 0.01
4	Chromium	0.05	<0.05
5	Fluoride	2.4	<4
6	Lead	0.05	<0.1
7	Mercury	0.002	<0.005
8	Selenium	0.2	<0.5
9	Silver	0.05	0.003 to 0.05
10	Endrin	0.0002	0.0002 to 10
11	Lindane	0.004	<10
12	Methoxychlor	0.1	0.05 to 4
13	Toxaphane	0.005	<0.005
14	Chlorophenoxys	0.1	<0.1
15	PH	6.5 to 8.5	4.0 to 10.0
16	Nitrate Nitrogen	10	0.25 to 10.0
17	Chloride	250	140 to 400
18	Copper	1	<=1
19	Iron	5	2 to 5
20	Zinc	5	2.1 to 15.3

5.1 Related diseases of water pollutants

There are many diseases related with the water pollutants. The related diseases of each pollutant, in this system, are adopted by EPA. For example, the following shows a few diseases related with some pollutant.

- (1) Arsenic
 - (i) Cause cancer (Liver, bladder, Lungs)
 - (ii) Birth defects
 - (iii) Can result in death
 - (iv) Irritation of stomach, and intestines
 - (v) Stomach ache, nausea, vomiting diarrhea
 - (vi) Decrease production of red and white blood cell
- (2) Barium
 - (i) Damage to kidneys
 - (ii) Damage to the lungs
 - (iii) Diarrhea
- (3) Cadmium
 - (i) Lung damage and fragile bones
 - (ii) Kidney disease

6. The Proposed System

The multi-agent system for water pollution using GA works as follows:

1. The user must input his or her water quality measurements in mg/l.
2. Intelligent agent will accept these water quality measurements and it will send them to diagnosis agent.
3. If the measurements are not in ranges, diagnosis agent will reply that "Invalid user measurements".
4. If the measurements are in ranges, diagnosis agent will send them to intelligent agent.
5. Intelligent agent will execute user's measurements with GA.
6. After executing, intelligent agent will reply the user whether water pollutes or not, if pollute, which attributes can cause water pollution and if not pollute, it will show the users "water is not polluting".
7. And, intelligent agent will send the resulted pollutant to diagnosis agent.
8. Diagnosis agent will extract the related diseases of the pollutant from Database.
9. Then, it will show the users the related diseases.

6.1 Data flow diagram of the system

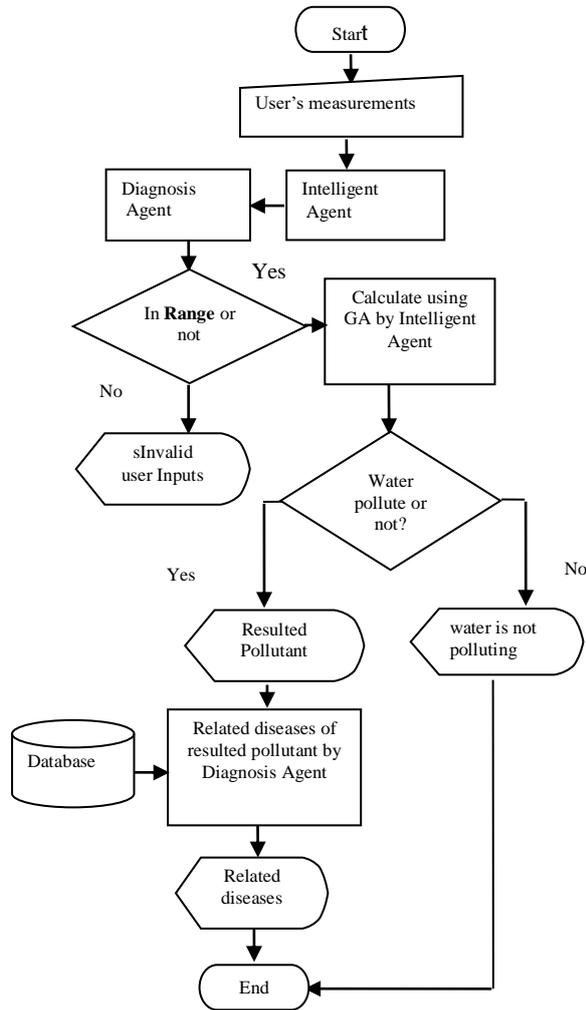


Figure2: Data flow diagram of the system

7. Experimental results

Some examples of experimented results of this proposed system are as following table.

Table2: Resulted pollutant cause of input pollutants and measurements

No	Input Pollutants and Measurements	Resulted Pollutant
1	Barium 0.5 Cadmium 0.005 PH 7 Iron 4	Cadmium
2	Fluoride 2.4 Mercury 0.0012	Mercury

	Silver Chloride	0.04 200	
3	Arsenic Silver Toxaphane PH	0.04 0.03 0.004 6.5	PH

According to the Table2, for No.1, the related diseases of resulted pollutants, cadmium are (1) very high levels severely irritates the stomach, leading to vomiting, (2) diarrhea, (3) kidney disease and (4) lung damage and fragile bones. For No.2, the corresponding diseases cause of mercury are (1) fatigue, headaches, lack of concentration and hair loss, destroying brain and (2) lateness in walking (on the infant). For No.3, the cause of the resulted pollutant, PH is causing many acutely toxic and chronic effects.

8. Conclusion

This system uses multi-agent and aims to be best for user or people who want to know whether water pollutes or not. And, in this system, if people know that water pollutes, they will also know the side effects of water pollution. GA helps to make decision whether water pollutes or not. By using this system, people will get knowledge concerned with water pollution.

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