# Knowledge Evolutionary Algorithm Based on Granular Computing


Yong-Qin Tao
[1]School of Computer Science and Engineering
Xi'an University of Technology
Xi'an, China
[2]Department of Computer Science and Technology
Xi'an Jiaotong University
Xi'an, China
tyq_123@126.com

Du-Wu Cui
School of Computer Science and Engineering
Xi'an University of Technology
Xi'an, China
cuidw@xaut.edu.cn

Tai-Shan Yan
School of Computer Science and Engineering
Xi'an University of Technology
Xi'an,China
yantaishan@163.com



***Abstract*—Granular computing makes mainly use of the information of different granularities and hierarchies to solve problems of the uncertain, fuzzy, imprecise, part true and a number of information. This paper has analyzed the evolutionary characteristics of knowledge granulation and has proposed the Evolution Algorithm of Knowledge Granulation (EAKG). EAKG Algorithm applies knowledge granulation to genetic programming and carries through the evaluation according to coverage degree and depends on degree to obtain some new rules. In addition, this paper has also given the recursive model of knowledge granulation evolution, crossover operator and mutation operator, etc. Through the experiments it has proved that it is the reasonable and effective to carry out solution of knowledge evolution with granule computing.**



***Keywords*—granular computing , evolutionary algorithm , knowledge granulation**


## I. Introduction

From the history of the mankind development, human progress and development are facilitated by the two types of the evolution. One is the natural evolution from Biological sense, which follows "of natural selection, survival of the fittest" principle of the evolution, It makes humanity continuously evolve from low to high and from simple to complex. The other is a knowledge evolution of human thinking oneself. The humanity has the capacity of the learning from the forward men and the winners, and constantly updates their knowledge and thinking. So that these make the progress of mankind have qualitative leap. Human regards knowledge evolution as its main features. These features are that all animals do not have the very important evolutionary characteristics except human [1]. Knowledge is a collective noun. It expresses the summation of mankind whole* understanding results [2]. However, the evolution and the growth of knowledge mean the evolution and growth of human cognition outcome. Otherwise, along with the emergence of the Internet and the number of the database, the knowledge acquired from them becomes the more and the more important, complicated and dynamic renewed. Among them the knowledge oneself has also characteristic of inheriting and innovation. This makes us want to probe into a kind of new method to deal with the knowledge mining. Granular Computing is a simulation of the analyzed capacity of the overall human. It can abstractly induce complex issues from different granular hierarchies into a relative simple model, then can carry through the analysis and solution to simple model, and can draw some properties and rules, etc.[3] We may make use of these properties and rules to guide future research. Some complex problem such as incomplete, uncertain and fuzzy knowledge can also be solved better. Therefore, the paper applies granule computing to knowledge evolutionary algorithms, probes into knowledge evolution, sums up some rules, presents the mode of the EAKG. The theory and the practice have proved that the method is feasible and effective.

## II. The Basic Concepts and Features of Knowledge Evolution

### A. the Basic Concepts of Knowledge evolution

Evolutionary Epistemology (EE) is a crossed and marginal subject. EE uses human cognitive ability and knowledge as the object of the study and the dynamic process. The infinity of the cognition development decides that the development of knowledge is also limitless [4]. Moreover, the continuous deepening of the cognition has also decided the continuous


* This paper is support by National Natural Science Foundation of P. R. China (No: 60743009)

development of knowledge and has incarnated the continuous progress of mankind understanding. At present, with the advent of the knowledge economy, knowledge and technology play an increasingly important role in human survival and evolution. Human will rely mainly on the knowledge and skills to seek development, to improve the quality of human existence, to expand living space. The development of knowledge can be divided into two basic forms. One is the system growth of the knowledge which mainly refers to a specific category of human knowledge as a status of the overall evolution. The other is the individual development of knowledge, which mainly refers to specific knowledge how to evolve into full knowledge individual from primary concept of the people's cognition and practice activity. If there are not knowledge individuals, there are also not knowledge categories. Then it will be impossible to have the whole of human knowledge. Whole knowledge relies on the evolution of the specific knowledge to implement. Therefore, the development of the knowledge individual is the basis and premises of whole knowledge development. And in the development process of the knowledge system, if the old knowledge can accelerate the evolution of humanity it will be preserved and developed. Otherwise, be eliminated. This is also the Inheritance of knowledge. In the process of Inheritance the people interact continuously with the environment and continuously apply the knowledge used to grasp new things and the environment, which results in the germination of new ideas. In addition, knowledge individuals propagate continuously the new knowledge individuals and gradually evolve into a new category. The various branches of knowledge generate also new knowledge through learning and interaction. This process is known as the innovation of knowledge. So the evolution of human knowledge is the unify process of knowledge inheritance and innovation.

## B. The Characteristics of the Knowledge Evolution

From the above process of knowledge evolution, it can be drawn that the evolution of knowledge also has the following main features in addition to the inheritance and innovation:

*1) Hierarchy features:* The concept forming and learning are the one of basic activities of the most human [6]. Concept is the basic unit of human knowledge. Usually, a concept correspond a word or phrase of the natural language. A concept may be the son concept of another concept, but also it may include many concepts, which determine that the human language also needs to be consistent with hierarchical structure. At the same time human memory also needs to be consistent with hierarchical structure .Only by doing these can people accurately describe and store knowledge. Human learning and accumulated depend on the intrinsic relation, tidiness and analysis between hierarchy concepts to a large extent.

*2) Dynamic feature:* With the development of networks and information, resources of information show explosive growth trend. Knowledge obtained from the network is the more and more important. Because the data that come from the web are half of the organization, and updated dynamically, which make obtained knowledge has the dynamic feature of the continuously increasing.

*3) Multi-dimensional feature:* In the data warehouse, the organization form of the data is to face main body, multi-dimensional and multi-hierarchy data cube. So these data have the characteristics of multi-dimension, complex hierarchy and great capacity, etc. In addition, the diversity of multimedia data has greatly enriched the form of the information expression, can reflect and describe the objective world through more natural vivid multimedia data, and is no longer confined to abstract numerical characters expression. Such information can not only expand the scope of the application, but also it can make people's interaction reach multi-dimension with machine.

*4) Multiformity:* There are different types of knowledge in realistic life. Knowledge can be divided into clear content knowledge and the self-evident hidden knowledge. The clear content knowledge means that the knowledge can be expressed with the language. It is also known as apparent knowledge. The self-evident hidden knowledge indicates that knowledge can not be expression with the languages. It is also known as the unconscious knowledge or latent knowledge. Clear content knowledge can be continuously divided into the processing and descriptive knowledge. The processing knowledge can explain how to solve problem, the illustrative knowledge is to judge knowledge right or wrong. The latent knowledge is uncertainty and integrated knowledge.

# III. THE BASIC CONCEPT OF KNOWLEDGE GRANULATION

## A. the Representation and the Definition of Knowledge Granulation

*Definition 1[7]:* The expressive system of knowledge granulation can be defined as follows:

$$S=(U,At=(C\cup D),L,\{V_a \mid a\in At\},\{I \mid a\in At\})$$

Where U is a finite nonempty set of objects, At is a finite nonempty set of granulation ,containing condition granulation set C and decision granulation set D,L is the decision logic language defined with granulation in At, $V=\bigcup_{a\in A} V_a$, $V_a$ is a nonempty set of values for $a\in At$ ,and $I_a$ , $U\to V_a$ is an knowledge granulation function.

*Definition 2[2]*: Suppose U is a finite nonempty set called domain. Any subset $X\subseteq U$ is called a conception in the U. A family of the concept in the U is called the knowledge about U and records as $A=\{X_1,X_2,\ldots, X_n\}$. If the satisfaction is as follows:

(1) $X_i \subseteq U, X_i \neq \varnothing$

(2) $X_i \cap X_j = \varnothing, i,j=1,2,\ldots,n$

(3) $\bigcup_{i=1}^{n} X_i = U$

Then A is called as the partition of the U

*Definition 3[8]:* Granulation is the object which gets the different size. That is to say, the big granule object can be divided into some small granule. Each small granule are further composed or decomposed into new granules so that new granules can describe the whole problem space or can solve the problem at different hierarchies.

The so-called knowledge granulation (KG) means a reflection of the limited capacity that human processes and stores knowledge. When humanity resolves and deals with the large number of complex knowledge, knowledge will be respectively divided into a number of the blocks according to features and performance of them due to the limited capacity of human beings. Each block is viewed as a knowledge granulation. This process of knowledge processing is called as knowledge granulation.

### *B. The Relation of Granular Degree, distinguishable degree and Entropy*

*Definition 4[2]* : Suppose K= (U, **R**) is a repository. R∈**R** is equivalence Relations in the universe U which is called knowledge. Granular degree of knowledge R ∈ **R** is represented as GD(R).It's definition is as follows:

$$GD(R)=\frac{|R|}{|U\times U|}=\frac{|R|}{|U|^2}$$

Where,| R| is the base of $R\subseteq U\times U$

*Property 1[2]*: Suppose R is knowledge of the repository K= (U, **R**), there are as follows:

$$\frac{1}{U}\leq GD(R)\leq 1$$

When R is equivalence relation, namely: When $R=\omega$, the granular degree of R reaches minimum size $\frac{|U|}{|U|^2}=\frac{1}{|U|}$

When R is a domain relation, namely: $R=\delta$, the granular degree of R reaches the maximum size $\frac{|U|^2}{|U|^2}=1$

*Definition 5[2]:* Distinguishable degree of knowledge R is represented .Its definition is as follows:

$$Dis(R)=1-GD(R)=1-\sum_{i=1}^{n}\frac{|X_i|^2}{|U|^2}$$

There is also $0\leq Dis(R)\leq 1-\frac{1}{|U|}$ where.

*Definition 6[2]:* Suppose P is knowledge of repository K=(U,R), U/P={$X_1,X_2,\ldots,X_n$}, Entropy H(P) of knowledge P is : $H(P)=-\sum_{i=1}^{n}p(X_i)\log_2 p(X_i)$

The value of entropy is a measurement of knowledge granulation. The relations of them are that when entropy H(R) is the greater, the GD (R) is less and distinguishable degree Dis (R) is stronger. Otherwise, they are the opposition.

### *C. Dealing with Knowledge Evolution with Granular Computing*

Knowledge granulations have hierarchy, dynamic, multi-dimensional, fuzzy, uncertainty, and other major characteristics and can carry through the operation of selection, crossover and mutation. There are some granules in each specific hierarchy. They are the mainstay of the different hierarchy .There are different types of knowledge granulation in the different hierarchy. They act each other, but they can not intersect. All granules in the same hierarchy form the coverage of this hierarchy and completely express the problem conception of this hierarchy. The granules of the different hierarchy are orderly arranged and interconnected together. Not only can the granules are decomposed and composed, two particles can also do the exchange (crossover) of some elements. From the angle of the granules, the dynamic process of knowledge evolution can actually be understood as follows: while the original pre- repository can consist of some original knowledge granules, these knowledge granulations are composed by a number of knowledge sub-granules. When the new knowledge granulations add into the original knowledge set, they search for suitable knowledge to judge and deal with the new knowledge and carry through the knowledge updating to various knowledge sub-granules. After dealing with the all new knowledge granulation, the knowledge sub-granulation are again composed and decomposed so as to gain new dynamic knowledge granulation.

## IV. EVOLUTIONARY ALGORITHM OF KNOWLEDGE GRANULATION

The paper has proposed the EAKG on the basis of knowledge evolutionary, granular computing and the genetic programming principle. The main characteristics of the genetic programming (GP) are that its chromosome structure is a hierarchy structure of dynamic change. It can be changed by the affection of the environment, so it is more rational to use GP to express the knowledge evolution. It can better complete the self-adaptive search and rule generating in the knowledge domain. In GP, the principal elements of composing the chromosome structure are the function and the variables / constants set. Chromosome structures carry through compounding and evolution processing in the formation so as to form the solutions of knowledge problem. These solutions can meet certain conditions in the prior-selected function set and variable / constants, according to some rules and the specific circumstances of the knowledge domain. Along with the environment changes chromosome structures evolve continuously and trend to perfecting, so as to achieve the optimal solution or satisfactory solution.

### *A. Multi-hierarchy of knowledge granulation*

Knowledge granulation has hierarchy structure. Namely: the hierarchy of knowledge cognition. The hierarchy of knowledge granulation has two ways. First is that knowledge granulation changes into more thin: A knowledge granulation can be divided into more small knowledge granules and can eliminate the incompatible knowledge granulation, which is the knowledge decomposition and knowledge Inheritance; Second is the universality of knowledge granulation: Two knowledge granules can be synthesized into greater knowledge granulation and can carry through the part change so as to form new knowledge granulation. Namely: the synthesis of knowledge granulation .That is , knowledge innovation.

For example: Table 1 is knowledge expressive system.

TABLE I: U={$x_1,x_2,x_3,x_4$},A={$A_1,A_2,A_3$}

| U | $A_1$ | $A_2$ | $A_3$ |
|---|---|---|---|
| $x_1$ | 1 | 1 | 0 |
| $x_2$ | 1 | 1 | 1 |
| $x_3$ | 0 | 1 | 1 |
| $x_4$ | 0 | 0 | 1 |

According to the different subset of knowledge granulation we can get a number of equivalence class relations in the domain. E.g:

$U/R_{a1}$={{ $x_1,x_2$},{$x_3,x_4$}}, $K_1=\sigma$ ($U/R_{a1}$)

$U/R_{a2}$={{ $x_1,x_2,x_3$},{$x_4$}}, $K_2=\sigma$ ($U/R_{a2}$)

$U/R_{a3}$={{ $x_1$},{ $x_2,x_3,x_4$}}, $K_3=\sigma$ ($U/R_{a3}$)

$U/R_{a1,a2}$ ={{ $x_1,x_2$},{ $x_3$},{$x_4$}}, $K_{12}=\sigma$ ($U/R_{a1,a2}$)

$U/R_{a1,a3}$ ={{ $x_1$},{$x_2$},{ $x_3, x_4$}}, $K_{13}=\sigma$ ($U/R_{a1,a3}$)

$U/R_{a2,a3}$ ={{ $x_1$},{$x_2$ , $x_3$},{$x_4$}}, $K_{23}=\sigma$ ($U/R_{a2,a3}$)

$U/R_{a1,a2,a3}$ ={{ $x_1$},{$x_2$ }, {$x_3$},{$x_4$}}, $K_{123}=\sigma$ ($U/R_{a1,a2,a3}$)

$U/R_{\varnothing}$ ={ $x_1, x_2, x_3, x_4$}, $K_0=\sigma$ ($U/R_{\varnothing}$)

It can be summed up that a different knowledge set can be partition different granules. If the equivalence relations contain more knowledge, its equivalent degree is the lower, the granular degree of individuals is much coarse, and the compounding property will also embodied worse. Thus, the different granules form a hierarchical structure. It is shown in Fig. 1:

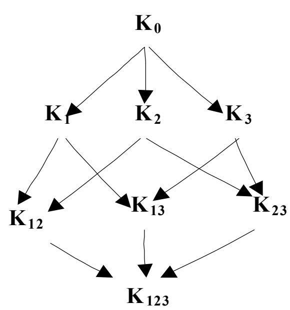


Figure 1: Multi-hiberarchy of knowledge granulation

*B. Inheritance and innovation of knowledge granulation evolution*

Inheritance of knowledge granulation is the decomposition and the removal of knowledge granulation. The innovation of knowledge granulation is the generalization process. The function set of genetic programming is the logical link word (such as ~、∧、∨、←→) of knowledge granulation. The variable / constants of genetic programming are the uncertainty knowledge and certainty knowledge of knowledge granulation. So the new rules (namely innovation) of knowledge granulation are generated by the operation of logical line word of knowledge granulation.

*Definition 7[5]:* Suppose $(\varphi,m(\varphi))$ and $(\psi,m(\psi))$ are two knowledge granulations, there are these logical operations as follows among them:

1) $\sim(\varphi,m(\varphi))=(-\varphi,U\text{-}m(\varphi))$;

2) $(\varphi,m(\varphi))\wedge(\psi,m(\psi))=(\varphi\wedge\psi,m(\varphi)\cap m(\psi))$;

3) $(\varphi,m(\varphi))\vee(\psi,m(\psi))=(\varphi\vee\psi,m(\varphi)\cup m(\psi))$;

4) $(\varphi,m(\varphi))\rightarrow(\psi,m(\psi))=(\varphi\rightarrow\psi,M)$,

When $m(\varphi)\subseteq m(\psi)$, $M=m(\varphi)$. Otherwise, $M=\psi$

5) $(\varphi,m(\varphi))\rightarrow(\psi,m(\psi))=(\varphi\leftarrow\psi,N)$,

When $m(\varphi)=m(\psi)$, $N=m(\varphi)$. Otherwise, $N=\psi$.

*Definition 8[5]:* Suppose $(\varphi,m(\varphi))$ and $(\psi,m(\psi))$ are two knowledge granulation, the definition of logical link word (—) about the minus is:

$$(\varphi,m(\varphi))\text{-}(\psi,m(\psi))=(\varphi,m(\varphi))\vee(\sim(\psi,m(\psi)))$$

This means that the granule $(\psi,m(\psi))$ is removed from granule $(\varphi,m(\varphi))$

*C. Evaluation Function*

*Definition 9:* Suppose $Y\subseteq U$ is a subset of the object which expresses some concepts in knowledge expressive system S, and $B\subseteq C$, In the approximate space ( U, B ), the Evaluation function of B is as follows:

$$\alpha_B(Y)=(|U|-|B^-Y-B\_Y|)/|U| \quad (1)$$

It describes the subjection degree of the object in confirmed granule B set, where $B^-Y$ and $B\_Y$ respectively denotes the sup-approximate class and sub-approximate class of Y.

*D. the Evolution Agorithm of Knowledge Granulation*

The step of EAKG operation is as follows:
Input: The system table of knowledge expression
Output: the rule set of knowledge granulation
Process:

*Step 1:* Ordering: j=1 Initialization knowledge granulation

*Step 2:* Ordering: $U'=U, C'=C, B=\varnothing, y=y_j$

*Step 3:* Computing the evaluation function of $S=(u,c,d,v,f)$ to all $c\in C', \alpha_{B'}(y)|B'=BU\{c\}$. Then, selecting the set of granule $B'=BU\{c\}$ according to the maximum value of the $\alpha_{B'}(y)$.

*Step 4:* if the $B\_(Y)=\varnothing$, go to 5. The included equivalence classes $\{C_1,C_2,...,C_r\}$ are identified by $B\_Y$ .Output certain decision rules:

$$\{des(c_k)\Rightarrow des(Y)\,|\,k=1,2,...,r\}$$

*Step 5:* Ordering: $U'=U'\text{-}((U'\text{-}B^-(Y))U(B\_(Y))$ and $Y=Y\text{-}B\_(Y)$, If the $U'=\varnothing$, go to 7).

Ordering: $C'=C'\text{-}B$. If the $C'\neq\varnothing$, go to 3)

*Step 6:* Output uncertain decision rules.

{The all equivalence classes $c_i'$ of equivalence relation $C'$ in the $des(c_i')\Rightarrow des(Y)|U'$ }

*Step 7:* order: j=j+1, If $j\le n$ go to 2).end.

Outputting: the decision rules of each class $y_i\in T$

## V. THE EXPERIMENT ILLUSTRATION AND ANALYSE

The experiment has been implemented by the C++ program design language in windows 2000 to more granules.

The follow is only example of EAKG.

1) An expressive system of knowledge granulation had shown in Table 2. It contains 3 condition knowledge granules, 1 decision knowledge granule, and 8 instances. Table 2 is used as an example to explain how to generate rules in evolutionary process of knowledge granulation with GKEA. Each object is described by knowledge granulation set C = (height, hair, eyes). The values of knowledge Granulation separately denote as Va = (short, tall ), Vb = (black, red, yellow), Vc = (blue, brown)

TABLE 2 :A EXPRESSIVE SYSTEM OF KNOWLEDGE GRANULES

| object | height | hair | eye | class |
|---|---|---|---|---|
| 1 | short | yellow | blue | 0 |
| 2 | short | yellow | brown | 1 |
| 3 | tall | red | blue | 0 |
| 4 | tall | dark | blue | 1 |
| 5 | tall | dark | blue | 1 |
| 6 | tall | yellow | blue | 0 |
| 7 | tall | dark | brown | 1 |
| 8 | short | yellow | brown | 1 |

2) Getting the basic class of table3 from table 2

TABLE 3: THE BASIC CLASS

| Formula: $\varphi = (a \in C, v)$ | C | Formula: $\psi = (a \in D, v)$ | D |
|---|---|---|---|
| (a, short) | $C_1$={1,2,8} | (a, 0) | $D_1$={1,3,6} |
| (a, tall) | $C_2$={3,4,5,6,7} | (a, 1) | $D_2$={2,4,5,7,8} |
| (a, yellow) | $C_3$={1,2, 6,8} | | |
| (a, red) | $C_4$={3} | | |
| (a, dark) | $C_5$={4,5, 7} | | |
| (a, blue) | $C_6$={1,3,4,5,6} | | |
| (a,brown) | $C_7$={2,7, 8} | | |

3) Computing the evaluation function $\alpha_c(y)$ .
U={1,2,3,4,5,6,7,8} $y_1$={1,3,6},$y_2$={2,4,5,7,8}
Ordering: Y=$y_1$= {1, 3, 6}, $y_1 \cap c_2 = \{3,6\} \neq c_2$.
The result of the computing is:
Height : $B^{-}Y = C_1 \cup C_2 = \{1, 2, 3, 4, 5, 6, 7, 8\}, B_{-}Y = \varnothing$

$$\alpha_a = \frac{(|U|-|B^{-}Y-B_{-}Y|)}{|U|} = \frac{8-(8-0)}{8} = 0$$

The same method:
Hair: $B^{-}Y = C_3 U C_4 = \{1, 2, 3, 6, 8\}$, $B_{-}Y = C_4 = \{3\}$

$$\alpha_b = \frac{8-(5-1)}{8} = \frac{4}{8} = 0.5$$

Eye: $B^{-}Y = C_6 = \{1, 3, 4, 5, 6\}, B_{-}Y = \varnothing$

$$\alpha_c = \frac{8-(5-0)}{8} = \frac{3}{8} = 0.375$$

When B= {hair}, $\alpha_b(y)$ is maximum

4) Ordering: The condition class $Q=\{c_1,c_2,...,c_m\}$ and the decision class $T=\{y_1,y_2,...,y_m\}$. When there is a $c_i \cap y_j = c_i$, the decision rule $\gamma_{ij}$ is certainly, 0therwise , uncertainly.
Height: $Q=\{c_1=(1,2,8), c_2=(3,4,5,6,7)\}$
Because $y_1 \cap c_1 = \{1\} \neq c_1$, $y_1 \cap c_2 = \{3,6\} \neq c_2$ ,
There is no certain rule.
Hair: $Q=\{c_3=(1,2,6,8), c_4=(3)\ ,\ c_5=(4,5,7)\}$ ,
$y_1 \cap c_3 = \{1,6\} \neq c_3$, $y_1 \cap c_4 = \{3\} = c_4$, $y_1 \cap c_5 = \varnothing \neq c_5$
Certain decision rule of $y_1$ is : $\gamma_{31}$:(hair:red) $\Rightarrow$ (d:0)
eye: $Q=\{c_6=(1,3,4,5,6), c_7=(2,7,8)\}$
$y_1 \cap c_6 = \{1,3,6\} \neq c_6$, $y_1 \cap c_7 = \varnothing_2 \neq c_7$ .
There is no certain rule
The same method: when $y_2$= {2, 4, 5, 7, 8},
$y_2 \cap c_i = c_i$ ( i = 5,7) , $y_2 \cap c_i \neq c_i$ ( i =1, 2, 3, 4, 6)
Certain Decision rule of $y_2$ is : $\gamma_{52}$:(hair:dark) $\Rightarrow$ (d:1) ,
$\gamma_{72}$:(eye:brown) $\Rightarrow$ (d:1)
5) Updating U, y with formula (1)
$U' = U' - ((U' - B^{-}(Y)) U (B_{-}(Y)) =$
$= \{\{1,2,3,4,5,6,7,8\} - ((\{1,2,3,4,5,6,7,8\} - \{1,2,3,6,8\}) \cup \{3\})$
$= \{1,2,6,8\} \neq \varnothing$
$Y = Y - B_{-}(Y) = \{1,3,6\} - \{3\} = \{1,6\}$
B= {hair, height}, B= {hair, eye}
6) B= (hair, height)
$= \{c_1', c_2', c_3', c_4'\} = \{\{1,2,8\},\{3\},\{4,5,7\}.\{6\},\}$
B= (hair, eye) = $\{c_5', c_6', c_7', c_8', c_9'\}$
$= \{\{\{1, 6\},\{2,8\},\{3\},\{4,5\},\{7\}\}$
Hair, height: $B_{-}Y = \{6\}, B^{-}Y = \{1,2,6,8\}$
Hai , eye: $B_{-}Y = \{1,6\}, B^{-}Y = \{1,6\}$

$$\alpha_{ab}(y) = \frac{4-(4-1)}{8} = \frac{1}{8} = 0.125,$$

$$\alpha_{bc}(y) = \frac{4-(2-2)}{8} = 0.5$$

7) The $\alpha_{bc}(y)$ is greater $y_1 \cap c_i' = c_i'$ ( i =4,5)
So certain decision rules of $y_1$ is as follows:
$\gamma_{41}'$=(heigth:tall,hair:yellow) $\Rightarrow$ (d,0) ,
$\gamma_{61}'$=(hair:yellow,eye:blue) $\Rightarrow$ (d,0)
The same method: $y_2 \cap c_8' = c_8'$ ,($c_8'$ ={4,5}
The certain decision rules of $y_2$ are:
$\gamma_{62}'$=(height:short,hair:yellow) $\Rightarrow$ (d,1) ,
8) $U' = U' - ((U' - B^{-}(Y)) U (B_{-}(Y))$
$= \{\{1,2,6,8\} - ((\{1,2,6,8\} - \{1,6\}) U \{1,6\}) = \varnothing$
$y_1$ : end

9) The rule hierarchy of knowledge granulation is as follows:

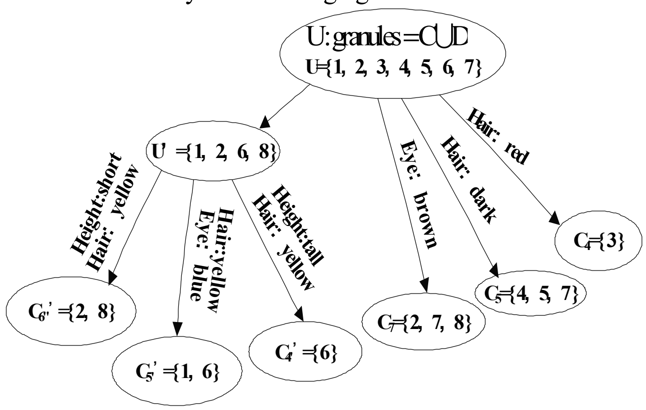


Figure 1. The rule hierarchy of knowledge granulation

10) Since RGS covers the all object in Table2, the cycle is end. Generating rules are:

The rule 1: if hair is dark then class=1
The rule2: if eye is brown then class=1
The rule 3: if hair is red then class=0
The rule 4: if height=tall and hair=yellow then class=0
The rule 5: if hair=yellow and eye=blue then class=0
The rule 6: if height=short and hair=yellow then class=1

## VI. CONCLUSION

Granular computing has been already explored in many fields. It can make us perceive the world and solve the problem of knowledge granulation in different hierarchy. After this paper has probed into the basic characteristics and method of granular computing and knowledge evolution, the granular computing will be applied in the knowledge evolution process. The paper has combined genetic programming with granular computing and has proposed evolution algorithms of knowledge granulation. The experiments have proved that EAKG algorithm is feasible and effective. Because it is only attempt to apply granule computing in knowledge evolution, Work in this area we need to be further studied

## REFERENCES


[1] A. Bourmistrova, and S. Khantsis,"Control System Design Optimisation via Genetic Programming," IEEE 2007 ,pp,1993~2000

[2] D.Q.miao,G.Y.Wang,"Granular Computing:Past,Now,Future", Science publishing house,2007

[3] Emiliano Carre˜no, Guillermo Leguizam´ on, Neal Wagner,"Evolution of Classification Rules for Comprehensible Knowledge Discovery," IEEE Congress on Evolutionary Computation,2007 ,pp,1262~1268

[4] Bernard Chen, Phang C. Tai, Robert Harrison and Yi Pan," Novel Efficient Granular Computing Model for Protein Sequence Motifs and Structure Information Discovery,"Sixth IEEE Symposium on BionInformatics and BioEngineering, 2006,pp,27(2)

[5] W.X.zhang, G.F.Qin.," Uncertain Decision Making on Rough Sets" Qinhua university publishing house,.2005

[6] Y.N.Guo,J.Cheng,"A Knowledge Based Hierachical Genetic Algorithm",Journal of China University of Mining &Technoloy,pp,772~776,Nov.2006

[7] J.J.An,G.Y.Wang,"A Rule Generation Algorithm based on Granular,"IEEE,2005,pp,102~107

[8] J.T. Yao,"Infornmation Granulation and Granular Relationships". IEEE,2005,pp,326~329