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ABSTRACT

The third session of IT@EDU98 consisted of five papers on educational software and was chaired by Tran Van Hao (University of Education, Ho Chi Minh City, Vietnam). "Courseware Engineering" (Nguyen Thanh Son, Ngo Ngoc Bao Tran, Quan Thanh Tho, Nguyen Hong Lam) briefly describes the use of courseware. "Machine Discovery Theorems in Geometry: A Helpful Tool in Teaching Geometry" (Hoang Kiem, Vu Thien Can) describes a system for discovering and proving theorems in the domain of plane geometry. "Model of Problems in Analytic Geometry and Automatically Solving" (Do Van Nhon) proposes a general model that can be used for representing problems of 3-dimensional analytic geometry. "Heuristic Based Scheduling in High School" (Nguyen Duc Thang) addresses scheduling teachers and classes in a high school. "A Model of Knowledge of Analytic Geometry" (Do Van Nhon) proposes the AG model, a model that can be used for representing knowledge of 3-dimensional analytic geometry, and discusses problems with constructing the knowledge base of 3-dimensional analytic geometry. (SWC)

SESSION 3

Thursday, 15 January 1998

Session 3: Educational software

Chair:
Prof. Tran Van Hao, University of Education, HCMC,Vietnam

3-1.**Courseware Engineering**
Nguyen Thanh Son,Ngo Ngoc Bao Tran, Quan Thanh Tho,Nguyen Hong Lam, University of Technology, HCMC-Vietnam

3-2. **Machine Discovery theorems in Geometry: A helpful tool in teaching Geometry**
Hoang Kiem, Vu Thien Can, University of Natural Sciences, HCMC,Vietnam

3-3. **Model of Problems in analytic geometry and automatically solving**
Do Van Nhon, University of Natural Sciences, HCMC,Vietnam

3-4.**Heuristic Based Scheduling in High School**
Nguyen Duc Thang, College of General Studies, HCMC,Vietnam

3-5.**Model of Knowledge of analytic geometry**
Do Van Nhon, University of Natural Sciences, HCMC,Vietnam

COURSEWARE ENGINEERING

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Quan Thanh Tho, Nguyen Hoang Lam
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Abstract

This report contains a method of engineering courseware. The method emphasizes on finding out the main ideas of the subject. From these ideas, the objectives and requirements are constructed. After that, the demonstration are performed on discrete mathematics and electronic experimentals of high school degree.

Contents

The courseware is an environment to help the studying. The environment assists to develop the structure of the lectures and to set up a control system. This system manages the activities of the learner. It also gives the feedbacks and evaluations on the activities of the user. The education and training are two main domains of the courseware.

First of all, the courseware satisfies the needs of education of everyone. In the situation of lacking teacher, courseware are considered as a teacher. Secondly, it assists teacher and learner. Thirdly, it standardizes the content and form of the lectures. Next, the courseware helps the learner to study all the life. At last, it contributes on the education emotionous and intellectual.

The courseware includes:

- Tutorial - Drill and practice
- Simulation - Game.

From the survey on discrete mathematics, the courseware should have the properties: generalization, specialization, computability, symbolization ...

Conclusion

The development of the courseware will support the standardization of the lecture and it will equalize the education degree between areas. Many programmers will get a lots of works from the development. Besides, the information technology will be progressed naturally. The responsibility of the young people in society will be increased. When developing, the priority of the specific and local problems will be higher than others. In the future, a data bank of courseware should be setup rapidly.

MACHINE DISCOVERY THEOREMS IN GEOMETRY: A Helpful Tool In Teaching Geometry

Hoang Kiem , Vu Thien Can
University of Natural Sciences, HCMC, Vietnam

Abstract

In teaching mathematics, especially geometry, the teacher's task for making students know how to find a problem is much more difficult than to solve a problem. The schools are teaching a set program of mathematics, rather how to do mathematics. Very few writers indeed have taken an interest in more active, as opposed to the usual passive, methods of teaching, to the phenomenon of discovery, to include reasoning , to the way the thought process works. There is a need to study the technical and cognitive aspects of the teaching process and to make a full evaluation of there.

Our aim is to help the teachers, as well as the students, to find the geometrical problems easily via experiments.

This paper describes a system for discovering and proving theorems in the domain of plane geometry. Our system generates geometrical figures by itself and acquires expressions describing relations among line segments and angles in the figures. Such expressions can be extracted from the numerical data obtained in the computer experiments. For proving theorems, we use the Wu's algorithm.

1.Discovering geometry theorems

1.1 We use the following two heuristics to discover geometry theorems

(H_1) drawing figures by adding lines.

(H_2) focusing on the expressions about lines segments and angles which are newly generated by the last additional line.

The former enables the system to draw various figures automatically and to acquire data by observing the figures. The latter avoids the combinatorial explosion without using knowledge for search.

1.2 Algorithm

The followings are the main steps of the algorithm.

Drawing figures

In order to draw various figures for the acquisition of data, lines are added one by one on a given base figure. In this paper, a circle is chosen as the base figure since many interesting figures can be drawn from a circle. To guide line drawing, focus points are introduced as the center of a circle, a point on the circumference, contact points, and intersection points. Lines are drawn on the following way according to the focus points:

From a focus point outside the circle

- Draw a tangential line to the circle
- Draw a line which passes through the center of the circle
- Draw an arbitrary line which has common points with the circle

From a focus point on the circle circumference

- Draw a tangential line which touches the circle at the focus point
- Draw a line which passes through the center of the circle
- Draw an arbitrary line to a point on the circumference

From a focus point outside the circle

- Draw a line which passes through the center of the circle
- Draw an arbitrary line which has common points with the circle

One can also draw a line parallel (or perpendicular) to a line joining two points in the figure and passing a point in the figure.

Figure 1 shows a part of drawn figures in the above way.

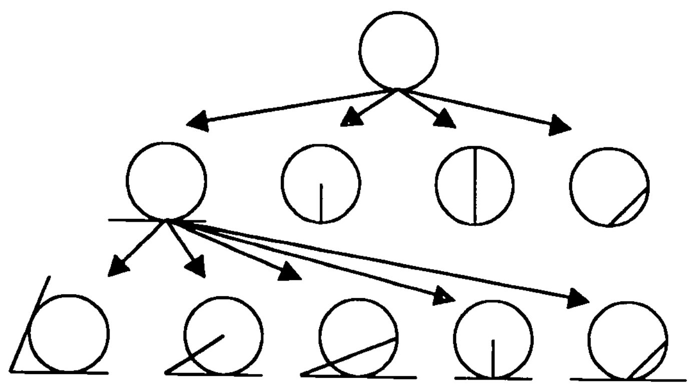
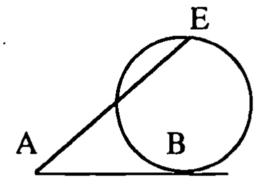


Figure 1

Acquisition of theoretical candidates

By observing the figure drawn in the above procedure, numerical data are acquired such as the length of line segments and the measure of angles. The length of line segments, and the sum and the product of the length of two arbitrary line segments are listed from the data. An expression, which we call a theoretic candidate, is acquired from two approximately equal numerical values in the list. From the data of angles also, theoretic candidates are acquired in the same manner.

Figure 2 shows a theoretic candidate : $AB^2 = AD.AE$



AB = 11.0	AB*AB = 121.0
BC = 7.5	AB*BC = 82.5
AC = 18.5	AB*AD = 91.3
AD = 8.3	.....
DE = 6.2	AD*AE = 120.4
AE = 24.5	....

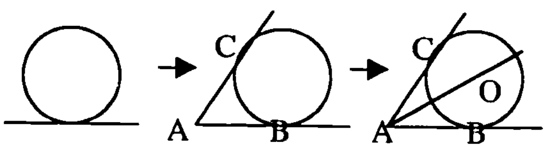
Figure 2

Selection of useful theoretic candidates

Many theoretic candidates are acquired from a figure. As additional lines are drawn on a figure, the number of line segments and angles increases, and the combination of line segments and angles increases accordingly. As a result, numerous theorematic candidates can be acquired from a complicated figure composed of many lines. To obtain only useful theorems from many acquired theorematic candidates, it is important to select useful theorematic candidates.

Let us focus on the relations of line segments and angles which are newly generated by drawing an additional line on a figure. Since theorematic candidates about the newly generated line segments and angles cannot be acquired from the figure before drawing additional line, such candidates can be considered useful.

Figure 3 shows the selection of useful theorematic candidate



AB = AC $\angle OAB = \angle OAC$

Figure 3

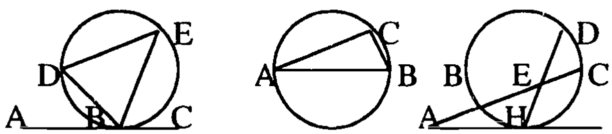
Verification of theorematic candidates

The theorematic candidates which hold only for the original figure, the figure from which they are acquired, are not true theorems. To remove such candidates, every candidate from the original figure should be tested whether the candidates holds for other figures which topologically resemble the original figure. Such figure are re-drawn by adding lines in the same order as the original figure. This is because the figures are used for making other experiments which resemble the one using the original figure. Since an additional line is drawn at random in length and in direction, re-drawn figures are, in general, partly different from the original figure. As a result of the above experiments, a theorematic candidate which holds for all the figures is regarded as a useful theorem of great generality.

1.3 Conclusion

We have proved that, using the above algorithm, the hypotheses and conclusions of the theorematic candidates acquired can be expressed by polynomial equations which coefficients are in a field E containing the field Q of all rational numbers as a subfield.

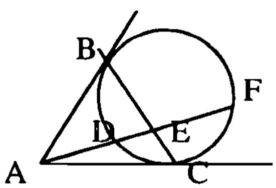
Using the above algorithm, we also rediscover many well-known theorems (Figure 4), as well as many theorems which are not found in a conventional book of geometry (Figure 5).



$\angle DEB = \angle DBA$ $\angle ACB = 90^0$ $AB.AC = AH^2$

$\angle EDB = \angle EBC$ $BE.BC = DE.EH$

Figure 5



$AE.AF = AC^2 + AD.EF$

$AD.AF = AE^2 + CE.CB$

$AD.AF = AE^2 + DE.EF$

$EF.AF = AD.DE + DF^2$

$AE.EF = DE.AF + CE.EB$

$AD.EF = AE.DE + CE.EB$

$AD.EF = DE.AF$

Figure 6

2.Proving Geometry Theorems

2.1 An overview of Wu's algorithm

Wu's method was introduced as a mechanical method for proving those statements in elementary geometries for which, in their algebraic forms, the hypotheses and the conclusion can be expressed by *polynomial equations*.

For a geometry statement (S), after adopting an appropriate coordinate coordinate system, the hypotheses can be expressed as a set of polynomial equations:

$h_1(u_1, ..., u_d, x_1, ..., x_t) = 0$

$h_2(u_1, ..., u_d, x_1, ..., x_t = 0$

....

$h_n(u_1, ..., u_d, x_1, ..., x_t) = 0$

and the conclusion is also a polynomial equation $g = g(u_1, ..., u_d, x_1, ..., x_t) = 0$; where $h_1, ..., h_n$ and g are polynomials in $Q[u_1, ..., u_d, x_1, .., x_t]$. Here $u_1, ..., u_d$ are parameters and $x_1, ..., x_t$ are dependent variables.

The assignment of parameters and variables is based on the following heuristics rules:

(1) Non-zero coordinates of an arbitrarily chosen point are parameters.

(2) If a point is constructed from one geometric condition, then one of its two coordinates is a parameter and the other is a variable.

(3) The two coordinates of a point constructed from two geometric conditions are variables.

It should be emphasized that these rules are based on the heuristic rule in algebra: one equation determines one unknown. It is the responsibility of the user to justify whether a point can be arbitrarily chosen or two conditions can really construct a point based on the geometric meaning of a given problem.

2.2 Some definitions and results

Pseudo Division

Let A be a computable commutative ring (e.g., $Q[y_1, ..., y_m]$). Let $f = a_nv^n + ... + a_0$ and $h = b_kv^k + ... + b_0$ be two polynomials in A[v], where v is a new indeterminate. Suppose k, the leading degree of h in v, is greater than 0. Then the pseudo division proceeds as follows:

First let $r = f$. Then repeat the following process until $m = deg(r,v) < k$: $r = b_kr - c_mv^{m-k}h$, where c_m is the leading coefficient of r. It is easy to see that m strictly decreases after each iteration. Thus the process terminates. At the end, we have the *pseudo remainder* *prem*(f,h,v) = r = r_0 and the following formula:

$$b_k^sf = qh + r_0 \text{, where } s \leq n - k + 1 \text{ and } deg(v_0, r) < deg(v, h).$$

Proposition: (The remainder formula)

Let $f_1, ..., f_r$ and R_0 be the same as above. There are some non-negative integers $s_1, ..., s_r$ and polynomials $Q_1, ..., Q_r$ such that:

(1) $I_1^{s1}.I_2^{s2} \ldots I_r^{sr}.g = Q_1.f_1 + Q_2.f_2 + \ldots + Q_r.f_r + R_0$ where the I_i are the leading coefficients of the f_i .

(2) $\deg(R_0, x_i) < \deg(f_i, x_i)$, for $i = 1,2,\ldots,n$.

A Triangulation Procedure: Ritt's Principle

Theorem: (Ritt's principle)

Let $S = \{h_1, \ldots, h_n\}$ be a finite nonempty polynomial set in $A = K[y_1, \ldots, y_m]$ and I be the ideal $(h_1, \ldots, h_n)$ of A.

There is an algorithm to obtain an ascending chain C such that either

- C consists of a polynomial in $K \cap I$ or
- $C = f_1, \ldots, f_r$ with $\text{class}(f_1) > 0$ and such that $f_i \in I$ and $\text{prem}(h_j, f_1, \ldots, f_r) = 0$ for all $i = 1, \ldots, r$ and $j = 1, \ldots, n$.

Ascending chain C is called *an extended characteristic set* of S.

Ritt's Decomposition Algorithm

Definition: A subset V of E^m is called an *algebraic set* if V is the set of common zeros of all elements of a nonempty polynomial set S, i.e.

$$V = \{(a_1, \ldots, a_m) \in E^m \mid f(a_1, \ldots, a_m) = 0 \text{ for all } f \in S\}$$

We often denote V by V(S).

Theorem: (Ritt's decomposition algorithm)

For any finite nonempty polynomial set S of A, there is an algorithm to decide whether Ideal(S) = (1) or (in the opposite case) to decompose

$$V(S) = V(P_1) \cup V(P_2) \cup \ldots V(P_s)$$

where P_i are prime ideals given by their irreducible characteristics sets.

Notion: Let E be any extension of the based field K. When we mention the algebraic set V(S), we mean the algebraic set V(S) in E^m.

The Algebraic formulation of Geometry Statements

Definition:

Let a geometry statement (S), in its algebraic form, be given by $u_1, \ldots, u_d, x_1, \ldots, x_r, h_1, \ldots, h_n$ and g, where u_i, x_i, h_i and g are the same as before. (S) is called generally true (or generally valid) if g vanishes on all non degenerate components $V(P_i^*)$ of $V = V(h_1, \ldots, h_n)$. "(S) is not generally true" is the negation of "(S) is generally true". If g vanishes on none of the nondegenerate components $V(P_i^*)$, the (S) is called generally false.

2.3 The Wu's method consists of the following steps

Step 1: Conversion of a geometry statement into the corresponding polynomial equations.

Step 2: Triangulation of the hypothesis polynomials using pseudo division.

Step 3: Successive pseudo division to compute the final remainder R_0. If $R_0 = 0$, then by the remainder formula we can infer the conclusion by adding the subsidiary or nondegenerate conditions available after triangulation. If R_0 is not zero, then the decomposition or check of irreducibility is needed to make further conclusions.

Step 4: Analysis of nondegenerate conditions $I_1 \neq 0, ..., I_r \neq 0$.

2.4 Some important results:

Theorem: Let (S), $h_1, ..., h_n$, g and $f_1, ..., f_r$ be the same as above. Suppose $f_1, ..., f_r$ is irreducible. If prem(g, $f_1, ..., f_r$) = 0 then:

(i) (S) is generally true, and

(ii) For all fields, ($h_1 = 0, ..., h_n = 0, I_1 \neq 0, ..., I_r \neq 0) \Rightarrow g = 0$, where the I_k are the leading coefficients of the f_k.

Theorem: Let (S), $h_1, ..., h_n$, g and $f_1, ..., f_r$ be the same as above. Suppose ascending chain $f_1, ..., f_r$ is irreducible. Let P be the prime ideal wih the characteristic set $f_1, ..., f_r$. Let E be the field associated with the geometry G. prem(g, $f_1, ..., f_r$) = 0 is the necessary condition for (S) to be generally true if one of the following conditions is satisfied:

(i) For E, V(P) is of degree d

(ii) E is algebraically closed field

(iii) $f_1, ..., f_r$ has a generic point in E.

Let C_i be the characteristic set of P_i as above.

Theorem: If prem(g,C_i) = 0 , i = 1,2,.., c then (S) is generally true.

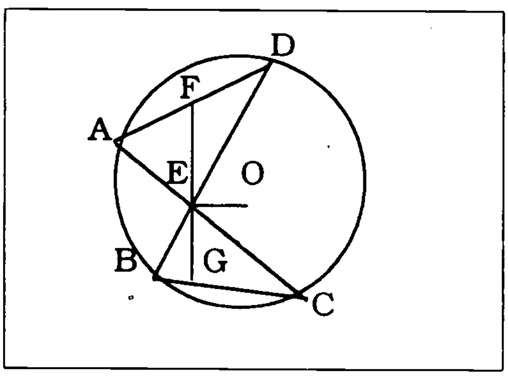
2.5 Conclusion

Using the above theorems, we can prove automatically whether or not a theorem is true.

3.An example

Generate figure

Figure 1 shows one figure generated by our system:



Acquisition of theorematic candidates

The observed numerical data:

OE = 7.5 EA = 8.5 ;EB = 6.2 ;EC = 8.4 ;ED = 11.02 ; EF = 7.8 ;EG = 7.7 ;

FA = 6.8 ;FD = 9.4 ;GB = 4.2 ;GC = 6.1 ;

We have: EF and EG are approximately equal.

Verification of theorematic candidates

The FIGURE 1 is re-drawn by adding lines in the same order as the original figure and we have the same result.

<u>*Theorem:*</u> (The Butterfly theorem)

A, B, C and D are four points on circle (O). E is the intersection of AC and BD. Through E draw a line perpendicular to OE, meeting AD at F and BC at G. We have EF = EG.

<u>*Proof*</u>:

Let E (0,0), O(u_1, 0), A(u_2, u_3), B(x_1, u_4), C(x_3, x_2), D(x_5 x_4), F(0, x_6), G(0, x_7). Then the hypotheses equations are:

$h_1 = x_1^2 - 2u_1x_1 + u_4^2 - u_3^2 - u_2^2 + 2u_1u_2 = 0$ OA = OB

$h_2 = x_3^2 - 2u_1x_3 + x_2^2 - u_3^2 - u_2^2 + 2u_1u_2 = 0$ OA = OC

$h_3 = u_3x_3 - u_2x_2 = 0$ Points C, A, E are collinear

$h_4 = x_5^2 - 2u_1x_5 + x_4^2 - u_3^2 - u_2^2 + 2u_1u_2 = 0$ OA = OD

$h_5 = u_4x_5 - x_1x_4 = 0$ Points D, B, E are collinear

$h_6 = (-x_5 + u_2)x_6 + u_3x_5 - u_2x_4 = 0$ Points F, A, D are collinear

$h_7 = (-x_3 + x_1)x_7 + u_4x_3 - x_1x_2 = 0$ Points G, B, C are collinear

The conclusion is $g = x_7 + x_6 = 0$.

We can let: $f_1 = h_1$, f_2 = prem(h_2, h_3, x_3), $f_3 = h_3$, f_4 = prem(h_4, h_5, x_6), $f_5 = h_5$, $f_6 = h_6$, $f_7 = h_7$ to obtain a triangular form:

$f_1 = -x_1^2 + 2u_1x_2 - u_4^2 + u_3^2 + u_2^2 - 2u_1u_2 = 0$

$f_2 = (-u_3^2 - u_2^2)\, x_2^2 + 2u_1u_2u_3x_2 + u_3^4 + (u_2^2 - 2u_1u_2)\, u_3^2 = 0$

$f_3 = -u_3x_3 + u_2x_2 = 0$

$f_4 = (-x_1^2 - u_4^2)\, x_4^2 + 2u_1u_4x_1x_4 + (u_3^2 + u_2^2 - 2u_1u_2)u_4^2 = 0$

$f_5 = -u_4x_5 + x_1x_4 = 0$

$f_6 = (-x_5 + u_2)x_6 + u_3x_5 - u_2x_4 = 0$

$f_7 = (-x_3 + x_1)x_7 + u_4x_3 - x_1x_2 = 0$

If we do successive pseudo divisions of g with respect to the above triangular form, then the final remainder R_0 is not zero. The reason is that the above triangular form is *reducible*. This reducibility comes from a special kind of degeneracy when using algebraic equations to encode certain geometric conditions. Equations h_2=0 and h_3=0 specify point

C: C is on circle (O) and on line AE. However, there are two points satisfying these equations: one is C; which we really want; the other point is A. Because A has been constructed before C, reducibility arises. We might use the Wu' method to deal with such reducibility. However, for such special reducibility, we can use elementary method, which is more satisfactory in geometry.

Because $f_2 = 0$ and $f_3 = 0$ have two solutions (one is for $A(u_2, u_3)$ and the other is for $C(x_3, x_2)$), $x_2 - x_3$ is a factor of f_2 under the previous geometric conditions: $f_2 = (x_2 - u_3)((-u_3^2 - u_2^2)x_2 - u_3^3 + (-u_2^2 + 2u_1u_2)u_3)$. Thus we can use the division to obtain $f_2^1 = (-u_3^2 - u_2^2)x_2 - u_3^3 + (-u_2^2 + 2u_1u_2)u_3$ and replace f_2 by f_2^1. In the same way, we have: $f_4 = (x_4 - u_4)f_4^1 + r$ where $f_4^1 = (-x_1^2 - u_4^2)x_4 - u_4x_1^2 + 2u_1u_4x_1 - u_4^3$, and $r = -u_4^2x_1^2 + 2u_1u_4^2x_1 - u_4^4 + (u_3^2 + u_2^2 - 2u_1u_2)u_4^2$.

We have $prem(r,f_1,x_1) = 0$. Hence, under the previous conditions $f_i = 0$ and $I_i \neq 0$ $(i=1,2,3)$: $f_4 = (x_4 - u_4)f_4^1$. We can replace f_4 by f_4^1 to obtain the nondegenerate triangular form $f_1, f_2^1, f_3, f_4^1, f_5, f_6, f_7$. Now we can do the successive divisions of g with respect o the new triangular form:

$R_6 = prem(R_7,f_7,x_7) = (-x_3 + x_1)x_6 - u_4x_3 + x_1x_2$

$R_5 = prem(R_6,f_6,x_6) = ((u_4 + u_3)x_3 - x_1x_2 - u_3x_1)x_5 + (-u_2x_3 + u_2x_1)x_4 - u_2u_4x_3 + u_2x_1x_2)$

$R_4 = prem(R_5,f_5,x_5) = (((-u_4 - u_3)x_1 + u_2u_4)x_3 + x_1^2x_2 + u_3x_1^2 - u_2u_4x_3)x_4 + u_2u_4^2x_3 - u_2u_4x_1x_2)$

$R_3 = prem(R_4,f_4^1,x_4) = ((-u_4^2 - u_3u_4)x_1^3 + (2u_1u_4^2 + 2u_1u_3u_4)x_1^2 + (-u_4^4 - u_3u_4^3 - 2u_1u_2u_4^2)x_1)x_3 + (u_4x_1^4 + ((u_2 - 2u_1)u_4)x_1^3 + u_4^3x_1^2 + u_2u_4^3x_1)x_2 + u_3u_4x_1^4 + (-u_2u_4^2 - 2u_1u_3u_4)x_1^3 + (u_3u_4^3 + 2u_1u_2u_4^2)x_1^2 - u_2u_4^4x_1)$

$R_2 = prem(R_3,f_3,x_3) = (-u_3u_4x_1^4 + (u_2u_4^2 + 2u_1u_3u_4)x_1^3 + (-u_3u_4^3 - 2u_1u_2u_4^2 - 2u_1u_2u_3u_4)x_1^2 + (u_2u_4^4 + 2u_1u_2^2u_4^2)x_1)x_2 - u_3^2u_4x_1^4 + (u_2u_3u_4^2 + 2u_1u_3^2u_4)x_1^3 + (-u_3^2u_4^3 - 2u_1u_2u_3u_4^2)x_1^2 + u_2u_3u_4^4x_1$

$R_1 = prem(R_2,f_2^1,x_2) = 2u_1u_2u_3^2u_4x_1^4 - (2u_1u_2^2u_3u_4^2 + 4u_1^2u_2u_3^2u_4)x_1^3 + (2u_1u_2u_3^2u_4^3 + 4u_1^2u_2^2u_3u_4^2 + (-2u_1u_2u_3^4 + (-2u_1u_2^3 + 4u_1^2u_2^2)u_3^2)u_4)x_1^2 + (-2u_1u_2^2u_3u_4^4 + (2u_1u_2^2u_3^3 + (2u_1u_2^4 - 4u_1^2u_2^3)u_3)u_4^2)x_1$

$R_0 = prem(R_1,f_1,x_1) = 0$

Since the final remainder R_0 is 0, the theorem follows from the following subsidiary conditions:

$I_2 = u_3^2 + u_2^2 \neq 0; I_3 = u_3 \neq 0; I_4 = x_1^2 + u_4^2 \neq 0; I_5 = u_4 \neq 0; I_6 = x_5 - u_2 \neq 0; I_7 = x_3 - x_1 \neq 0;$

4.Conclusion

We have described an approach for discovering useful theorems in the domain of plane geometry by employing experimentation. Our system discovers theorems by using nothing but the heuristics of drawing figures and the heuristics on focusing on newly generated line segments and angles. We have rediscovered theorems in conventional documents of plane geometry. We have also discovered a number of of usefule theorems.

Logically, we have used Wu's algorithm for demonstrating the preciseness of these theorems. Additionally, we have determined that the above theorems can be proved by Wu's algorithm. For illustration: The Butterfly Theorem.

The topic we mentioned in the paper can be leaded in two ways:

(1) With the above discovery, whether any proofs are needed ?

(2) If needed, whether any manipulations more simple than Wu's algorithm to prove the preciseness of the theorems we have found ?

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MODEL OF PROBLEMS IN ANALYTIC GEOMETRY AND AUTOMATICALLY SOLVING

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Abstract

Our aim is to analyze and design a system for solving problems in 3-dimensional analytic geometry. We would like to produce a useful program for students in learning mathematics. We researched some problems to construct the components in the structure of the system.

In this paper we propose a general model that can be used for representing problems of 3-dimensional analytic geometry according to the model AG. By this modeling we have some algorithms to solve automatically problems in 3-dimensional analytic geometry on computer. So we can construct an inference engine of the program that solve problems in analytic geometry.

1. The model of problems in analytic geometry.

1.1 General form of problems

Consider problems in 3-dimensional analytic geometry we can see that each of them has the hypothesis part and the conclusion part (or the question part, goal). The hypothesis and the conclusion have the following forms.

1.1.1. Hypothesis

According to AG model the hypothesis of problems may consists of some or all of the cases below:

- Given objects in which there are some objects that is determined and another objects are not determined. For example, the point A(1,2,3) and the plane (P) which has the equation 2x+3y-z=0 are determined objects, the line (d) which has the unique fact that passes the point A is not determined.

- Some attributes of the objects may be given by parameters.

- We may also have some geometry relations between objects in the hypothesis. For example, the line (d) / / the plane (P).

- Some computing relations may be given in the hypothesis. For example, u + v = w.

1.1.2. Question or goal of problems

In analytic geometry problems questions or goal has the general form which consists of some of the following cases:

- Determine an object or an attribute (or some attributes) of an object.
- Compute the value of parameters.
- Prove a relation between objects.
- Find some relations between objects.

1.2. Model of a problem

From the general form of problems in the above subsection we see that a problem can be represented by the sets below:

$$O = \{O_1, O_2, \ldots, O_n\},$$
$$R = \{r_1, r_2, \ldots, r_m\},$$
$$F = \{f_1, f_2, \ldots, f_p\}.$$

In the model the set O consists of n objects, R is the set of facts that give geometry relations between objects, and F consists of computing expressions on the objects or their attributes. In the set F there are also equalities that give us the values of some attributes of objects.

The goal of problem may be one of the followings:

- Determine an object.
- Determine an attribute (or some attributes) of an object.
- Consider a relation between objects.
- Find a relation between objects.
- Find an expression relative to some objects.
- Compute a parameter (or some parameters).
- Compute a value relative to objects such as the distance between a point and a line.

Example: Given the points E and F, and the line (d). Suppose E, F, and (d) are determined. (P) is the plane satisfying the relations: E $\in$ (P), F $\in$ (P), and (d) // (P). Find the general equation of (P).

In this exercise the objects and the facts are listed in the tables below:

Kind of object	Name of object	determination
point	E	yes
point	F	yes
line	D	yes
plane	P	no

The geometry relations between objects:

Kind of relation	Name of object	Name of object
$\in$	E	P
$\in$	F	P
//	D	P

Expressions: don't have.

The goal of the problem:

Goal	Object	Name of object	attribute
Attribute	plane	P	*equation*

2. Solving problems

2.1. Forward Chaining Algorithm

From the idea of the forward chaining algorithm we can find out a solution of the problem by the following algorithm:

Algorithm 1:

step 1. Record the objects in the problem and the goal of the problem.

step 2. Initialize the solution be empty.

step 3. Record the facts given (hypothesis):

- Determination of objects.
- Relations between objects.
- Expressions relative to objects.
- Attributes which are determined of objects.

step 4. Test the goal. **If** the goal obtained **then goto** the reducing step (step 9).

step 5. Search for the rule that can be applied to produce new facts or new objects.

step 6. if the search in step 5 fail **then**

conclusion: Solution not found, and **stop**.

step 7. if the search in step 5 success **then**

record the information about the rule found into the solution,

and the new facts or new objects produced by applying the rule.

step 8. goto step 4.

step 9. Reducing the solution found.

2.2. Forward Chaining Algorithm with heuristics

To find out a solution more quickly we will use heuristic rules in the above algorithm. Consider the way people solve the problems we use heuristic rules in our algorithm. The followings are some of the rules we use.

Rule 1. priority to use the rules for determining objects, features of objects. For examples:

- A point which has coordinates known is determined.
- A point and a perpendicular vector of a plane will determine the plane.
- A plane which has the equation known is determined.
- A line which has two points determined is determined.

Rule 2. priority to use the rules for producing new relations relative to the goal.

Rule 3. priority to use the rules for producing new objects relative to the goal. For examples:

- A plane has two points determined $\Rightarrow$ produce a direction vector of the plane.
- A line (d) determined and (d) // a plane (P) $\Rightarrow$ produce a direction vector of the plane (P).
- A line (d) determined and (d) $\perp$ a plane (P) $\Rightarrow$ produce a perpendicular vector of the plane (P).
- A line (d) determined and (d) $\subseteq$ a plane (P) $\Rightarrow$ produce a direction vector of the plane and a point in the plane (P).

Rule 4. priority to use backward chaining step in the case it has one branch.

Rule 5. priority to determine the object has relations to the goal.

Rule 6. if a parameter need to be determined then we should use computing rules and operations.

Rule 7. If we could not produce new facts or objects then use parameters and equations.

By using heuristic rules we have the folowing algorithm:

Algorithm 2:

step 1-4. The same as the algorithm1.

Step 5. Use heuristic rules to select a good direction for producing new facts or objects and obtain a new situation.

step 6. if selecting in step 5 success **then**

record a stage in the solution, and **goto** step 4.

step 7. Search for the rule that can be applied to produce new facts or new objects.

step 8. if the search in step 7 fail **then**

conclusion: Solution not found, and **stop**.

step 9. if the search in step 7 success **then**

record the information about the rule found into the solution,

and the new facts or new objects produced by applying the rule.

step 10. goto step 4.

step 11. Reducing the solution found.

2.3. Using patterns

Solving many problems we can see that there are patterns of problems usually met. Recording those patterns and their solutions will help us improve the solving of problems. From the algorithm 2 we can write down the algorithm 3 in which there is the step for considering the ability to use patterns. However, the algorithm 3 is not written here. Belows are some patterns of problems:

- Pattern 1: Find the plane passes the intersection of two planes and passes a point.
- Pattern 2: Find the plane passes two lines.
- Pattern 3: Find the plane perpendicular to two planes and passes a point.

2.4. Testing algorithms

In the above algorithm we need some algorithm for testing the determination of objects. The following is the algorithm for testing the determination of a plane.

Algorithm for testing the determination of a plane (P)

1. Compute number of points determined in (P): d.
2. Compute number of vectors determined perpendicular to (P): n.
3. **if** $(d \geq 1)$ **and** $(n \geq 1)$ **then** P is determined

   else continue step 4.
4. **if** $(d \geq 3)$ **and** (there are 3 points of (P) that are not alignment) **then**

   P is determined

   else continue step 5.
5. Compute number of vectors determined parallel to (P): u.
6. **if** $(d \geq 1)$ **and** $(u \geq 2)$ **and**

   (there are 2 vectors v1, v2 not parallel each other and they parallel to P) **then**

   P is determined.

3. Examples

Example 1:

Given the points E and F, and the line (d). Suppose E, F, and (d) are determined. (P) is the plane satisfying the relations: E ∈ (P), F ∈ (P), and (d) // (P). Find the general equation of (P).

Solution:

By the algorithm 2 we have a solution consists of the following steps:

1. E ∈ (P), F ∈ (P) produce a vector u // (P). (rule 2 &3)
2. (d) // (P) produce a vector v // (P). (rule 3)
3. (P) is determined. (rule 1)
4. we have the equation of (P) from the object (P). (rule 1)

Example 2

Given the planes (Q1) and (Q2), and the line (d). Suppose (Q1), (Q2), and (d) are determined. (P) is the plane satisfying the relations: (d) // (P), and (P) passes the intersection of (Q1) and (Q2),. Find the general equation of (P).

Solution:

By the algorithm 2 we have a solution consists of the following steps:

1. (d) // (P) produce a vector v // (P). (rule 3)
2. Produce a line (d') such that: (d') ⊆ (P), (d') ⊆ (Q1), (d') ⊆ (Q2).
3. (d') is determined.
4. produce a point M determined in (P) and a vector v // (P).
5. (P) is determined. (rule 1)
6. we have the equation of (P) from the object (P). (rule 1)

4. Conclusions

The method of modeling problems in the above sections and algorithms for solving problems represent a natural way to solve the problems of people. It help us to design and implemented programs that can automatically solve exercises in 3-dimensional analytic geometry. We hope that our results may be developed and applied in the design and implement program that can automatically solve different problems

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HEURISTIC BASED SCHEDULING IN HIGH SCHOOL

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1. Scheduling problem and Min-Conflicts Heuristic

1.1. Scheduling problem

- Scheduling is the process of selecting among alternative plans and assigning resources and times to the set of activities in the plans. The assignments must obey a set of rules or constraints that reflect the temporal relationships between activities and the capacity limitations of a set of shared resources.
- Scheduling have been shown to be an NP-hard problem (Garey & Johnson, 1979; Graves, 1981; French, 1982).

1.2. The Min-Conflicts Heuristic

A constraint-satisfaction problem (CSP) consists of a set variables and a set of constraints. A solution is an assignment specifying a value for each variable, such that all the constraints are satisfied.

The min-conflicts heuristic includes two phases :

Preprocessing phase: generating an initial assignment for all variables. Two variables conflict if their values violate a constraint.

Repairing phase: repeating to repair constraint violations until a consistent assignment is achieved. This phase can be characterized by following procedure : *Select a variable that is in conflict and assign it a value that minimizes the number of conflicts.*

This procedure results in a hill-climbing search.

2. Scheduling in High School

2.1. School scheduling problem

Given : Let L= {Lessons(Teacher, Subject, Class)} be a set of lessons and D a set of time-slots in a week.

Require : Assign a value Di ∈ D for each lesson Li ∈ L so that all the constraints are satisfied. Essential constraints include :

-No class and no teacher can have more than one lesson at a time,

-a teacher has unavailable time-slots,

-the lessons of a class in a day must be continuous ,

-a teacher has a limit on the number of all lessons in a day and a limit on the number of lessons of a class in a day,

-a set of lessons must be taken simultaneously,

2.2. The criteria to evaluate quality of school time-table

2.2.1. Defining the priority point for teacher

-Teachers are principal factor to realizing STB (*school time-table*). A teacher has a private situation determining his/her priority if there is any difficulty in scheduling.

-Priority point of the teachers PP(t) is defined as follow :

PP(t) = Priority Point(teacher) = 1 for every teacher. In addition, PP(t) will be added :
+ 1, if the teacher is female,

+ 1, if the teacher is female and has baby,

+ 1, if the teacher is old.

PP(t) = 5 in special case.

2.2.2. The conception of an "un -arrangable lesson"

A time slot Di $\in$ D is "assignable" for a lesson Lj $\in$ L if it can be assigned to Lj so that all constraints are satisfied. If an "assignable" Di for lesson Lj is not existing then Lj will be called "un-arrangable" into STB .

2.2.3. The penalty point of school time-table

When there is an "un-arrangable" lesson of a teacher with priority point PP(t) = K , the STB will incur penalty point = K. The penalty point of the STB is :

$P = \sum_t N_t * PP(t)$; N_t : number of "un-arrangable" lessons of teacher t.

2.2.4. The fragment of school time-table

When a teacher's arranged lessons in a day are not continuous, they are called fragment. Most teachers don't want their lessons to be fragment.

time-slot	Mon	Tue	Wed	Thu	Fri	Sat
1						class 9A2
2		class 8A2			class 8A3	class 8A1
3						
4						
5					class 9A1	

Figure 1 : The time-table of a teacher with fragment point = 5

-The fragment point of a teacher in a day is defined as follows :

FP(t, d) = 0, if the teacher t hasn't any lesson in the day d

= 3, if the teacher t has only one lesson in the day d

= number of the teacher's empty time-slots of his/her lessons in the day d.

-The fragment point of STB is : $F = \sum_t \sum_d FP(t,d)$

2.2.5. The quality of STB

The quality based on 3 criteria:

1. With the same a set of data, less "un-arrangable" lessons, the better STB is. The main goal of scheduling is minimizing a number of "un-arrangable" lessons into STB.

2. If two STBs have an equal number of " un-arrangable" lessons, less fragment point, the better STB is.

3. If two STBs have an equal number of " un-arrangable" lessons, less penalty point, the better STB is.

3. Implement the scheduling

The scheduling system includes two phases : *initial assignment* and *repairing school time-table.*

3.1. The initial assignment

Purpose: Creating initial STB with most lessons assigned assignable values.

Method : Using principle of order, the more lessons, the more priority is.

In following schema, LC is a set of the "un-arrangable" lessons .

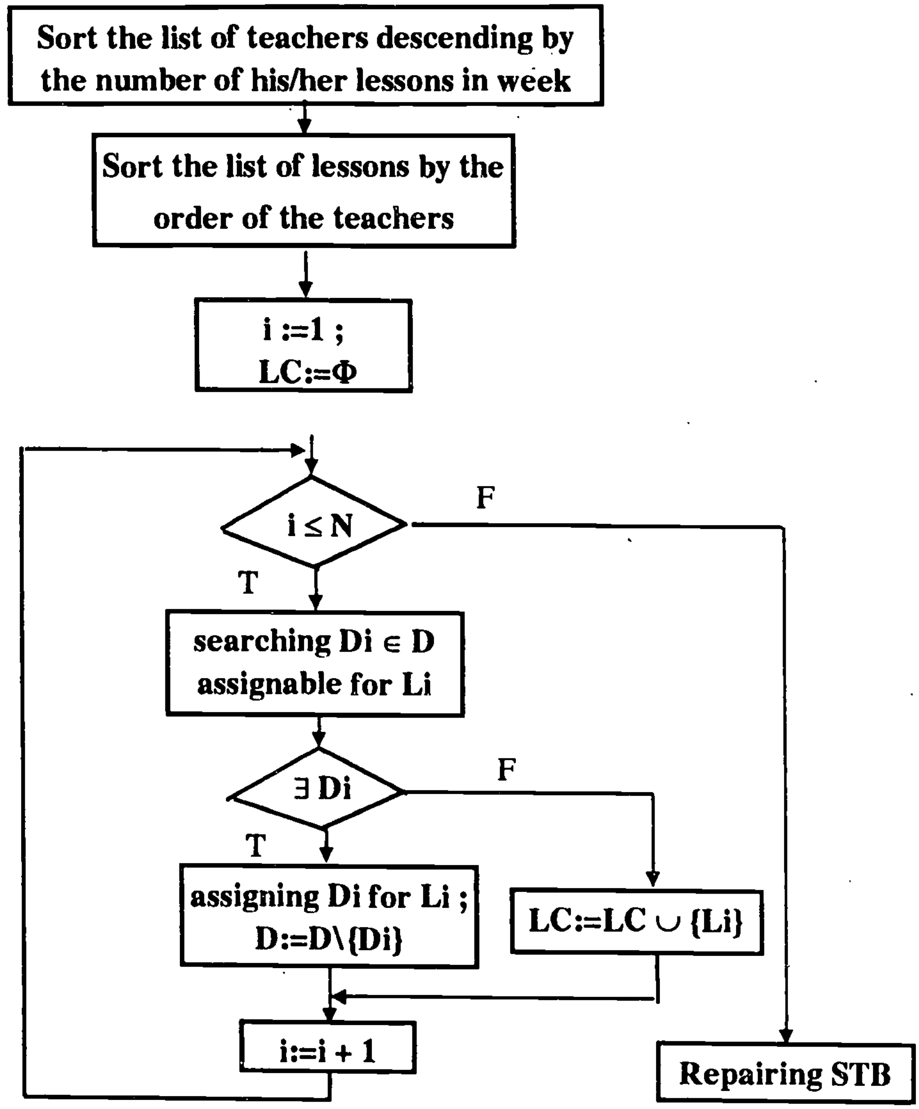

Figure 2: Schema of the initial assignment
(*N : number of lessons*)

3.2. The repairing STB

3.2.1 General schema of the repairing STB

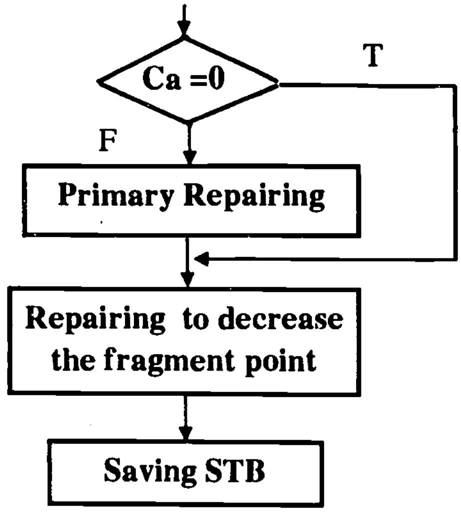

Figure 3: General schema of the repairing STB
(*Ca : Cardinality(LC)*)

3.2.2. The primary repairing STB

Purpose :Minimizing the Cardinality(LC) while reducing the fragment point and penalty point of STB.

Step 1 : Sort the list of teachers descending by the priority point of the teachers.

Step 2 : Sort the list of lessons $\in$ LC by the order of the teachers.

Step 3 : For each lesson LCi $\in$ LC , swap the values assigned for the lessons $\in L \setminus LC$ to search a value Di "assignable" for LCi, and then assign Di for LCi.

Step 4 : Repeat step 2 and step 3 until LC = Φ.

In the step 3, there are some special procedures. Below just is the illustration of the procedure named Vertical Repairing.

Let LCi $\in$ LC be an " un-arrangable" lesson of the class X and L1, L2,..., Ln be lessons arranged into time-table of the class X .

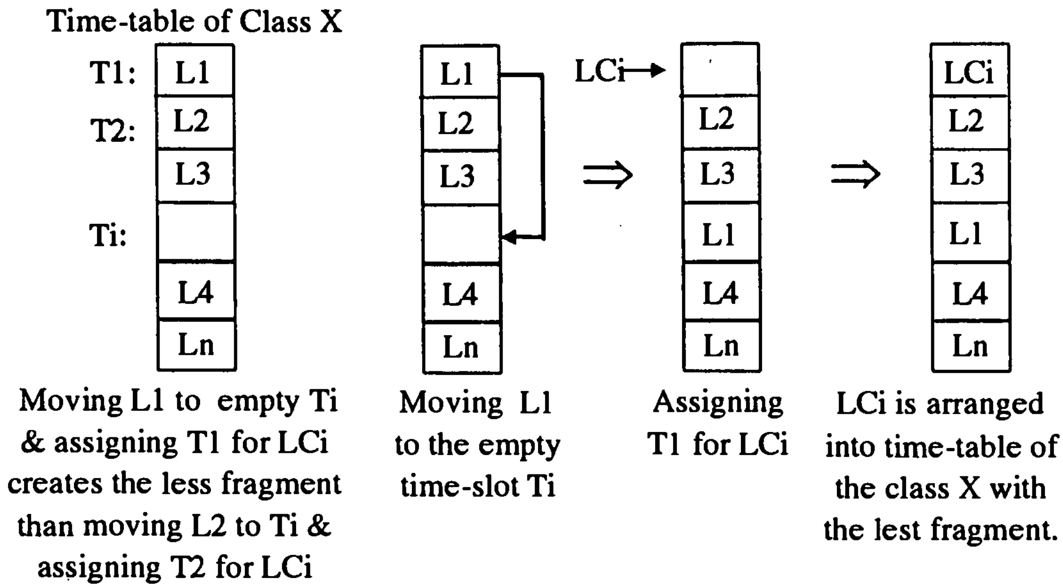

Figure 4: A effective case of vertical repairing

3.2.3. Repairing to decrease the fragment

Purpose: Minimizing the fragment point of STB.

Step 1: Un-assigning values Di assigned for Li that creates high fragment point, and add Li into LC,

Step 2 : Call the procedure primary repairing,

Step 3 : Repeat step 1 and step 2 until fragment point of STB < a constant ε.

4. The applications and the pending questions

The system is applied to the scheduling problems for three schools in Ho Chi Minh city: Tran Van On secondary school, ThanhDa high school and GoVap evening continuation high school. The qualities of the time-tables are rather good.

However, fragment points of the some teachers were still high.

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The appendix

1. The database

Scheduling problem at Tran Van On secondary school includes 14 classes (class 7A1,.., class 7A14), 28 teachers, 30 weekly time-slots, and 350 lessons. A teacher, which is the head of a class, has more one lesson CỜ and one lesson SHCN. The lessons CCỜ of all classes are simultaneous, the lessons SHCN are similar.

The unavailable days for the lessons of the subjects :

1. Monday :	SỬ , ĐỊA	4. Thursday:	GDCD
2. Tuesday :	TOÁN, LÝ	5. Friday:	SINH, ANH
3. Wednesday:	HÓA ,VĂN	6. Saturday :	KỸ.T

Below is the database of the problem.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
No	Name	code	Subj	head of	class 7A1	class 7A2	class 7A3	class 7A4	class 7A5	class 7A6	class 7A7	class 7A8	class 7A9	class 7A10	class 7A11	class 7A12	class 7A13	class 7A14	Σ less	PP(t)
1	Thuận	VA2	VĂN	7A4	5			5								5			17	2
2	Yến	VA4	VĂN	7A11			5							5	5				17	2
3	Trang	TO1	TOÁN	7A1	5	5								5					17	2
4	Hường	TO3	TOÁN	7A6			5		5	5									17	2
5	Hội	TO6	TOÁN	7A8								5	5				5		17	2
6	Thể	SI1	SINH		2		2	2	2	2	2				2	2			16	6
7	Lộc	LY2	LÝ		2		2	2	2	2	2						2	2	16	6
8	Mai	VA3	VĂN									5	5				5		15	2
9	Thảo	VA5	VĂN						5	5	5								15	1
10	Vân	AV4	ANH	7A5					4			4		4					14	2
11	Nga	AV2	ANH	7A9	4								4					4	14	2
12	Nghĩa	SI2	SINH	7A14		2						2	2	2			2	2	14	2
13	Trân	DI1	ĐỊA		2		2	2	2	2	2				2				14	2
14	Hiền	LY1	LÝ	7A10		2						2	2	2	2	2			14	2
15	Thanh	AV3	ANH	7A3		4	4										4		14	2
16	Hùng	DI2	ĐỊA			2						2	2	2		2	2	2	14	1
17	Lan	TO2	TOÁN	7A7				5			5								12	2
18	Lợi	VA1	VĂN	7A2		5												5	12	2
19	Nhi	AV5	ANH					4		4	4								12	2
20	Danh	TO4	TOÁN												5	5			10	6
21	Hương	SU2	SỬ	7A13		1						1	1	1	1	1	1	1	10	2
22	Hằng	AV1	ANH	7A12											4	4			10	2
23	Chính	GD1	GDCD			1	1	1	1	1		1	1	1	1	1			10	1
24	Thu	KY2	KỸ.T			1						1	1	1	1	1	1	1	8	2
25	Nhung	SU1	SỬ		2		1	1	1	1	2								8	2
26	Thủy	KY1	KỸ.T		1		1	1	1	1	1								6	2
27	Diệp	TO5	TOÁN															5	5	2
28	Chi	GD2	GDCD														1	1	2	2

Database of scheduling problem at Tran Van On school

2. The Initial School time table :

Number of un-arrangable lessons : 21 Arrangable ratio : 94%

Penalty point : 68 Fragment Point : 77

Class	7A1	7A2	7A3	7A4	7A5	7A6	7A7	7A8	7A9	7A10	7A11	7A12	7A13	7A14
2.1	ANH (Nga)	TOÁN (Trang)	GDCD (Chính)	TOÁN (Lan)	TOÁN (Hường)	ANH (Nhi)	VĂN (Thảo)	ANH (Vân)	VĂN (Mai)	VĂN (Yến)	SINH (Thể)	VĂN (Thuận)	TOÁN (Hội)	LÝ (Lộc)
2.2		TOÁN (Trang)	KỸ.T (Thủy)	TOÁN (Lan)	TOÁN (Hường)	LÝ (Lộc)	SINH (Thể)	ANH (Vân)	VĂN (Mai)	VĂN (Yến)	LÝ (Hiền)	VĂN (Thuận)	TOÁN (Hội)	ANH (Nga)
2.3	KỸ.T (Thủy)	SINH (Nghĩa)	ANH (Thanh)	VĂN (Thuận)	VĂN (Thảo)	TOÁN (Hường)	TOÁN (Lan)	VĂN (Mai)	TOÁN (Hội)	TOÁN (Trang)	VĂN (Yến)	SINH (Thể)	LÝ (Lộc)	ANH (Nga)
2.4	TOÁN (Trang)	VĂN (Lợi)	ANH Thanh)	VĂN (Thuận)	ANH (Vân)	TOÁN (Hường)	TOÁN (Lan)	TOÁN (Hội)	ANH (Nga)	LÝ (Hiền)	VĂN (Yến)	ANH (Hằng)	VĂN (Mai)	SINH (Nghĩa)
2.5	CCỜ (Trang)	CCỜ (Lợi)	CCỜ (Thanh)	CCỜ (Thuận)	CCỜ (Vân)	CCỜ (Hường)	CCỜ (Lan)	CCỜ (Hội)	CCỜ (Nga)	CCỜ (Hiền)	CCỜ (Yến)	CCỜ (Hằng)	CCỜ (Hương)	CCỜ (Nghĩa)
3.1		ANH (Thanh)		ĐỊA (Trân)	ANH (Vân)	SINH (Thể)	VĂN (Thảo)	SINH (Nghĩa)	ANH (Nga)	VĂN (Yến)	ANH (Hằng)	VĂN (Thuận)	VĂN (Mai)	VĂN (Lợi)
3.2	VĂN (Thuận)	ANH (Thanh)	VĂN (Yến)	ANH (Nhi)	SINH (Thể)	ĐỊA (Trân)	VĂN (Thảo)	GDCD (Chính)	SINH (Nghĩa)	ANH (Vân)	ANH (Hằng)	ĐỊA (Hùng)	VĂN (Mai)	VĂN (Lợi)
3.3	VĂN (Thuận)	VĂN (Lợi)	VĂN (Yến)	SINH (Thể)	SỬ (Nhung)	VĂN (Thảo)	ANH (Nhi)	ĐỊA (Hùng)	VĂN (Mai)	ANH (Vân)		SỬ (Hương)	SINH (Nghĩa)	KỸ.T (Thu)
3.4	ANH (Nga)	ĐỊA (Hùng)	SINH (Thể)	GDCD (Chính)	KỸ.T (Thủy)	VĂN (Thảo)	ANH (Nhi)		VĂN (Mai)	SINH (Nghĩa)	KỸ.T (Thu)	ANH (Hằng)	ANH (Thanh)	GDCD (Chi)
3.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
4.1	SỬ (Nhung)	SINH (Nghĩa)	ANH (Thanh)	ANH (Nhi)	GDCD (Chính)	TOÁN (Hường)	TOÁN (Lan)	ANH (Vân)	ANH (Nga)	TOÁN (Trang)	ĐỊA (Trân)	SINH (Thể)	TOÁN (Hội)	LÝ (Lộc)
4.2		ANH (Thanh)	SỬ (Nhung)	TOÁN (Lan)	ĐỊA (Trân)	TOÁN (Hường)	LÝ (Lộc)	ANH (Vân)	SINH (Nghĩa)	TOÁN (Traug)	SINH (Thể)	LÝ (Hiền)	TOÁN (Hội)	ANH (Nga)
4.3		TOÁN (Trang)		TOÁN (Lan)	TOÁN (Hường)	ĐỊA (Trân)	SINH (Thể)	SINH (Nghĩa)	TOÁN (Hội)	ANH (Vân)	LÝ (Hiền)	ĐỊA (Hùng)	LÝ (Lộc)	ANH (Nga)

3.4.9

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Lớp	7A1	7A2	7A3	7A4	7A5	7A6	7A7	7A8	7A9	7A10	7A11	7A12	7A13	7A14
4.4	ANH (Nga)	TOÁN (Trang)	LÝ (Lộc)	TOÁN (Lan)	TOÁN (Hường)	SINH (Thể)	GDCD (Nhung)	LÝ (Hiền)	TOÁN (Hội)	ANH (Vân)	SỬ (Hương)	TOÁN (Danh)	SINH (Nghĩa)	ĐỊA (Hùng)
4.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
5.1	VĂN (Thuận)	ĐỊA (Hùng)	VĂN (Yến)	LÝ (Lộc)	SINH (Thể)	VĂN (Thảo)	ANH (Nhi)	TOÁN (Hội)	LÝ (Hiền)	KỸ.T (Thu)	ANH (Hằng)	TOÁN (Danh)	ANH (Thanh)	VĂN (Lợi)
5.2	VĂN (Thuận)	LÝ (Hiền)	VĂN (Yến)	SINH (Thể)	LÝ (Lộc)	VĂN (Thảo)	ANH (Nhi)	TOÁN (Hội)	SỬ (Hương)	ĐỊA (Hùng)	ANH (Hằng)	TOÁN (Danh)	ANH (Thanh)	TOÁN (Diệp)
5.3	TOÁN (Trang)	ANH (Thanh)	TOÁN (Hường)	ĐỊA (Trân)	VĂN (Thảo)	LÝ (Lộc)	SINH (Thể)	VĂN (Mai)	KỸ.T (Thu)	SỬ (Hương)	TOÁN (Danh)	ANH (Hằng)	ĐỊA (Hùng)	TOÁN (Diệp)
5.4	TOÁN (Trang)	ANH (Thanh)	TOÁN (Hường)	VĂN (Thuận)	VĂN (Thảo)	ANH (Nhi)	ĐỊA (Trân)	VĂN (Mai)	ĐỊA (Hùng)	VĂN (Yến)	TOÁN (Danh)	LÝ (Hiền)	KỸ.T (Thu)	LÝ (Lộc)
5.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
6.1	SỬ (Nhung)	VĂN (Lợi)	ĐỊA (Trân)	TOÁN (Lan)	KỸ.T (Thủy)	VĂN (Thảo)	LÝ (Lộc)	KỸ.T (Thu)	VĂN (Mai)	TOÁN (Trang)	VĂN (Yến)	VĂN (Thuận)	TOÁN (Hội)	ĐỊA (Hùng)
6.2	LÝ (Lộc)	LÝ (Hiền)	TOÁN (Hường)	GDCD (Chính)	ĐỊA (Trân)	SỬ (Nhung)	VĂN (Thảo)	ĐỊA (Hùng)	TOÁN (Hội)	TOÁN (Trang)	VĂN (Yến)	VĂN (Thuận)	VĂN (Mai)	VĂN (Lợi)
6.3	ĐỊA (Trân)	TOÁN (Trang)	TOÁN (Hường)	KỸ.T (Thủy)	LÝ (Lộc)	GDCD (Chính)	VĂN (Thảo)	SỬ (Hương)	TOÁN (Hội)	VĂN (Yến)	TOÁN (Danh)	KỸ.T (Thu)	VĂN (Mai)	VĂN (Lợi)
6.4	TOÁN (Trang)	KỸ.T (Thu)	LÝ (Lộc)	VĂN (Thuận)	VĂN (Thảo)	KỸ.T (Thủy)	TOÁN (Lan)	TOÁN (Hội)	LÝ (Hiền)	VĂN (Yến)	GDCD (Chính)	TOÁN (Danh)	ĐỊA (Hùng)	SỬ (Hương)
6.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
7.1	VĂN (Thuận)	SỬ (Hương)	VĂN (Yến)	TOÁN (Lan)	TOÁN (Hường)	ANH (Nhi)	ĐỊA (Trân)	VĂN (Mai)	GDCD (Chính)	ĐỊA (Hùng)	SINH (Thể)	TOÁN (Danh)	LÝ (Lộc)	TOÁN (Diệp)
7.2	ANH (Nga)	VĂN (Lợi)	TOÁN (Hường)	TOÁN (Lan)	ANH (Vân)	ANH (Nhi)	SINH (Thể)	VĂN (Mai)	ĐỊA (Hùng)	SINH (Nghĩa)	TOÁN (Danh)	GDCD (Chính)	TOÁN (Hội)	TOÁN (Diệp)
7.3	TOÁN (Trang)	VĂN (Lợi)	ĐỊA (Trân)	VĂN (Thuận)	ANH (Vân)	TOÁN (Hường)	TOÁN (Lan)	TOÁN (Hội)	ANH (Nga)	LÝ (Hiền)	VĂN (Yến)	SỬ (Hương)	ANH (Thanh)	SINH (Nghĩa)
7.4	SHCN (Trang)	SHCN (Lợi)	SHCN (Thanh)	SHCN (Thuận)	SHCN (Vân)	SHCN (Hường)	S'HCN (Lan)	SHCN (Hội)	SHCN (Nga)	SHCN (Hiền)	SHCN (Yến)	SHCN (Hằng)	SHCN (Hương)	SHCN (Nghĩa)
7.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#

3. The School time table repaired:

Number of un-arrangable lessons : 0 Arrangable ratio : 100%

Penalty point : 0 Fragment Point : 79

Lớp	7A1	7A2	7A3	7A4	7A5	7A6	7A7	7A8	7A9	7A10	7A11	7A12	7A13	7A14
2.1	ANH (Nga)	TOÁN (Trang)	GDCD (Chính)	LÝ (Lộc)	TOÁN (Hường)	VĂN (Thảo)	KỸ.T (Thủy)	LÝ (Hiền)	VĂN (Mai)	VĂN (Yến)	SINH (Thể)	VĂN (Thuận)	SINH (Nghĩa)	TOÁN (Diệp)
2.2	SINH (Thể)	TOÁN (Trang)	KỸ.T (Thủy)	ANH (Nhi)	TOÁN (Hường)	LÝ (Lộc)	VĂN (Thảo)	ANH (Vân)	VĂN (Mai)	GDCD (Chính)	LÝ (Hiền)	VĂN (Thuận)	TOÁN (Hội)	ANH (Nga)
2.3	KỸ.T (Thủy)	SINH (Nghĩa)	ANH (Thanh)	VĂN (Thuận)	VĂN (Thảo)	TOÁN (Hường)	TOÁN (Lan)	VĂN (Mai)	TOÁN (Hội)	TOÁN (Trang)	VĂN (Yến)	SINH (Thể)	LÝ (Lộc)	ANH (Nga)
2.4	TOÁN (Trang)	VĂN (Lợi)	ANH (Thanh)	VĂN (Thuận)	ANH (Vân)	TOÁN (Hường)	TOÁN (Lan)	TOÁN (Hội)	ANH (Nga)	LÝ (Hiền)	VĂN (Yến)	ANH (Hằng)	VĂN (Mai)	SINH (Nghĩa)
2.5	CCỜ (Trang)	CCỜ (Lợi)	CCỜ (Thanh)	CCỜ (Thuận)	CCỜ (Vân)	CCỜ (Hường)	CCỜ (Lan)	CCỜ (Hội)	CCỜ (Nga)	CCỜ (Hiền)	CCỜ (Yến)	CCỜ (Hằng)	CCỜ (Hương)	CCỜ (Nghĩa)
3.1	ĐỊA (Trân)	GDCD (Chính)	ANH (Thanh)	SỬ (Nhung)	ANH (Vân)	SINH (Thể)	VĂN (Thảo)	SINH (Nghĩa)	ANH (Nga)	VĂN (Yến)	ANH (Hằng)	VĂN (Thuận)	VĂN (Mai)	VĂN (Lợi)
3.2	ANH (Nga)	ANH (Thanh)	VĂN (Yến)	ANH (Nhi)	SINH (Thể)	ĐỊA (Trân)	VĂN (Thảo)	GDCD (Chính)	SINH (Nghĩa)	ANH (Vân)	ANH (Hằng)	ĐỊA (Hùng)	VĂN (Mai)	VĂN (Lợi)
3.3	VĂN (Thuận)	VĂN (Lợi)	VĂN (Yến)	SINH (Thể)	SỬ (Nhung)	VĂN (Thảo)	ANH (Nhi)	ĐỊA (Hùng)	VĂN (Mai)	ANH (Vân)	ĐỊA (Trân)	ANH (Hằng)	GDCD (Chi)	KỸ.T (Thu)
3.4	VĂN (Thuận)	ĐỊA (Hùng)	SINH (Thể)	ĐỊA (Trân)	VĂN (Thảo)	ANH (Nhi)	SỬ (Nhung)	ANH (Vân)	VĂN (Mai)	SINH (Nghĩa)	KỸ.T (Thu)	ANH (Hằng)	ANH (Thanh)	GDCD (Chi)
3.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
4.1	GDCD (Nhung)	SINH (Nghĩa)	ANH (Thanh)	ANH (Nhi)	GDCD (Chính)	TOÁN (Hường)	TOÁN (Lan)	ANH (Vân)	ANH (Nga)	TOÁN (Trang)	ĐỊA (Trân)	SINH (Thể)	TOÁN (Hội)	LÝ (Lộc)
4.2	SINH (Thể)	ANH (Thanh)	SỬ (Nhung)	ANH (Nhi)	ĐỊA (Trân)	TOÁN (Hường)	LÝ (Lộc)	ANH (Vân)	SINH (Nghĩa)	TOÁN (Trang)	TOÁN (Danh)	LÝ (Hiền)	TOÁN (Hội)	ANH (Nga)
4.3	LÝ (Lộc)	TOÁN (Trang)	SINH (Thể)	TOÁN (Lan)	TOÁN (Hường)	ĐỊA (Trân)	ANH (Nhi)	SINH (Nghĩa)	TOÁN (Hội)	ANH (Vân)	LÝ (Hiền)	ĐỊA (Hùng)	SỬ (Hương)	ANH (Nga)

Lớp	7A1	7A2	7A3	7A4	7A5	7A6	7A7	7A8	7A9	7A10	7A11	7A12	7A13	7A14
4.4	ANH (Nga)	TOÁN (Trang)		LÝ (Lộc)	TOÁN (Hường)	SINH (Thể)	ĐỊA (Trân)	LÝ (Hiền)	TOÁN (Hội)	ANH (Vân)	SỬ (Hương)	TOÁN (Danh)	SINH (Nghĩa)	ĐỊA (Hùng)
4.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
5.1	VĂN (Thuận)	ĐỊA (Hùng)	VĂN (Yến)	LÝ (Lộc)	SINH (Thể)	VĂN (Thảo)	TOÁN (Lan)	TOÁN (Hội)	LÝ (Hiền)	SINH (Nghĩa)	ANH (Hằng)	TOÁN (Danh)	ANH (Thanh)	VĂN (Lợi)
5.2	VĂN (Thuận)	LÝ (Hiền)	VĂN (Yến)	SINH (Thể)	LÝ (Lộc)	VĂN (Thảo)	ANH (Nhi)	TOÁN (Hội)	SỬ (Hương)	ĐỊA (Hùng)	ANH (Hằng)	TOÁN (Danh)	ANH (Thanh)	TOÁN (Diệp)
5.3	TOÁN (Trang)	ANH (Thanh)	TOÁN (Hường)	SỬ (Nhung)	VĂN (Thảo)	KỸ.T (Thủy)	ANH (Nhi)	VĂN (Mai)	KỸ.T (Thu)	SỬ (Hương)	TOÁN (Danh)	ANH (Hằng)	ĐỊA (Hùng)	TOÁN (Diệp)
5.4	TOÁN (Trang)	VĂN (Lợi)	TOÁN (Hường)	KỸ.T (Thủy)	VĂN (Thảo)	ANH (Nhi)	SỬ (Nhung)	VĂN (Mai)	ĐỊA (Hùng)		TOÁN (Danh)		KỸ.T (Thu)	
5.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
6.1	GDCD (Nhung)	VĂN (Lợi)		ĐỊA (Trân)	TOÁN (Hường)	VĂN (Thảo)	LÝ (Lộc)	LÝ (Hiền)	VĂN (Mai)	TOÁN (Trang)	VĂN (Yến)	VĂN (Thuận)	TOÁN (Hội)	ĐỊA (Hùng)
6.2		LÝ (Hiền)	TOÁN (Hường)	TOÁN (Lan)	ĐỊA (Trân)	LÝ (Lộc)	VĂN (Thảo)	ĐỊA (Hùng)	TOÁN (Hội)	TOÁN (Trang)	VĂN (Yến)	VĂN (Thuận)	VĂN (Mai)	VĂN (Lợi)
6.3		TOÁN (Trang)	TOÁN (Hường)	VĂN (Thuận)	LÝ (Lộc)	GDCD (Chính)	VĂN (Thảo)	SỬ (Hương)	TOÁN (Hội)	VĂN (Yến)	ĐỊA (Trân)	LÝ (Hiền)	VĂN (Mai)	VĂN (Lợi)
6.4	TOÁN (Trang)	KỸ.T (Thu)	LÝ (Lộc)	VĂN (Thuận)	VĂN (Thảo)	SỬ (Nhung)	ĐỊA (Trân)	TOÁN (Hội)	LÝ (Hiền)	VĂN (Yến)	GDCD (Chính)	TOÁN (Danh)	ĐỊA (Hùng)	SỬ (Hương)
6.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#
7.1	VĂN (Thuận)	SỬ (Hương)	VĂN (Yến)		VĂN (Thảo)	ANH (Nhi)	GDCD (Nhung)	VĂN (Mai)	GDCD (Chính)	ĐỊA (Hùng)		TOÁN (Danh)	ANH (Thanh)	TOÁN (Diệp)
7.2	SINH (Thể)		TOÁN (Hường)		ANH (Vân)	ANH (Nhi)		VĂN (Mai)	ĐỊA (Hùng)		TOÁN (Danh)	GDCD (Chính)	GDCD (Chi)	TOÁN (Diệp)
7.3	TOÁN (Trang)	VĂN (Lợi)	ANH (Thanh)	VĂN (Thuận)	ANH (Vân)	TOÁN (Hường)	TOÁN (Lan)	TOÁN (Hội)	ANH (Nga)	LÝ (Hiền)	VĂN (Yến)	ANH (Hằng)	SỬ (Hương)	SINH (Nghĩa)
7.4	SHCN (Trang)	SHCN (Lợi)	SHCN (Thanh)	SHCN (Thuận)	SHCN (Vân)	SHCN (Hường)	SHCN (Lan)	SHCN (Hội)	SHCN (Nga)	SHCN (Hiền)	SHCN (Yến)	SHCN (Hằng)	SHCN (Hương)	SHCN (Nghĩa)
7.5	#	#	#	#	#	#	#	#	#	#	#	#	#	#

A MODEL OF KNOWLEDGE OF ANALYTIC GEOMETRY

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Abstract

Our aim is to analyze and design a system for solving problems in 3-dimensional analytic geometry. We would like to produce a useful program learning mathematics. We researched some problems to construct the components in the structure of the system.

In this paper we propose a model that can be used for representing knowledge of 3-dimensional analytic geometry called AG model. We also discuss some problems to construct knowledge base of 3-dimensional analytic geometry.

1. The AG-model for representing knowledge

One of the applications of Information Technology in education is to produce programs for supporting learning and teaching. Our subject is to analyze and design a system that can solve exercises in 3-dimensional analytic geometry. First of all, we need a model for representing knowledge of analytic geometry. The model will be a tool which help us to organize and implement the knowledge base of the system. In the following we propose the AG model for representing knowledge.

Our **AG model** consists of five sets Co, Ca, O, R, and L. We denote the model by

(Co, Ca, O, R, L).

Each set in the model is described as follows:

Co is the set of concepts. Each concept is concerned with a kind of objects. An object has attributes and between them there are internal relations which are manifested in the following features of the object:

- Given a subset A of attributes of the object. The object can show us the attributes that can be determined from A.
- The object will give us the value of an attribute if we request it.
- One object can also show us the internal process of determining the attributes.
- The object can give us the answer about the determination of object.

For example, the concepts "point", "vector".

Ca is the set of concepts relative to objects. These concepts may be concerned with attributes of objects. The concepts in Ca may also be concerned with values or objects can be produced from another objects by certain rules. For example: coordinates of a point, equation of a line.

O is the set of operations such as dot product (or scalar product) of two vectors, and cross product of two vectors.

R is the set of kinds of relations between objects such as parallelism between two vectors, perpendicular between two vectors.

L is the set of rules. Each rule gives us a way for computing and/or deducing something relative to concepts, operations and relations.

In many subjects knowledge may be represented as AG model. In the next sections we will represent knowledge of 3-dimensional analytic geometry by the AG model.

2. Knowledge of 3-dimensional analytic geometry & AG model.

2.1. Knowledge of 3-dimensional analytic geometry

A part of knowledge of 3-dimensional analytic geometry is listed as follows:

2.1.1 The Cartesian coordinate system.

2.1.2 The concept "point" and some relatives:

- Coordinates of a point.
- Projection of a point on a line or on a plane.
- Distance or length between two points.
- Alignment of three points or more.

2.1.3 The concept "vector" and some relatives:

- Coordinates of a vector.
- Projection of a vector on a vector, on a line or on a plane.
- The vector between two points.
- The angle of two vectors.
- Operations on vectors: addition, subtraction, etc ...
- Relations between vectors: parallelism, perpendicular, etc ...
- Theorems and formulas.

2.1.4 The concept "plane" in space and relatives:

- Direction vectors of a plane.
- Perpendicular vector of a plane.
- A point belonging to a plane.
- Equation of a plane.

- Angle between two planes

- Relations between planes, etc .

2.1.5 The concept "line" and some relatives:

- Direction vector of a line.

- A point is belongs to a line.

- Equation of a line.

- Angle between two lines.

- Relations between lines, etc ...

2.1.6 Some rules:

- $u \perp v, u // w \Rightarrow v \perp w$

- $u // v, u \perp w \Rightarrow v \perp w$

- $u \perp v \Leftrightarrow u.v = 0$

2. 2. Dimensional analytic geometry Knowledge based on AG model.

From the list of knowledge in the above we can represent the of 3-dimensional analytic geometry knowledge based on AG model as follows:

2.2.1 The set Co consisting of the concepts: point, vector, plane, line, etc ...

2.2.2 The set Ca consisting of the following concepts:

- Coordinates (of a point, of a vector).

- Magnitude or length (of a vector).

- Direction vectors (of a plane).

- Perpendicular vector (of a plane).

- Equation (of a plane, of a line).

- Relative position (of two planes, of two lines, etc.).

- Intersection, etc.

2.2.3 The set O consisting of the following operations:

- Operations on vectors: addition, subtraction, scalar product, cross product, etc ..

- Distance computing.

- Intersection computing.

- Compute the angle (between two vectors, between two planes).

- Projection Computing, etc....

2.2.4 The set R consisting of the relations such as parallelism, perpendicular, alignment.

2.2.5 The set L consists of rules. They can be classified into following classes:

- Geometric relations.
- Properties of operations.
- Rules relative to computing expressions.

2.2.6 The set of objects and facts relative to the Cartesian coordinate system. It consists of the point O, the axes Ox, Oy, Oz, etc ....

3. Organization of Knowledge base

3.1. Components of knowledge base

Concerning the above representation of the knowledge, we can be organized the knowledge into the following components.

3.1.1 The dictionary of concepts about kinds of objects, attributes, operations, relations, computing values or objects, etc ....

3.1.2 Table for descriptions of structure and features of objects. For example, when a plane is determined we can ask it to compute and give us its attributes such as the equation of the plane, a perpendicular vector of the plane.

3.1.3 Rules for determining objects.

3.1.4 Rules for computing values or objects.

3.1.5 Rules or properties of the operations.

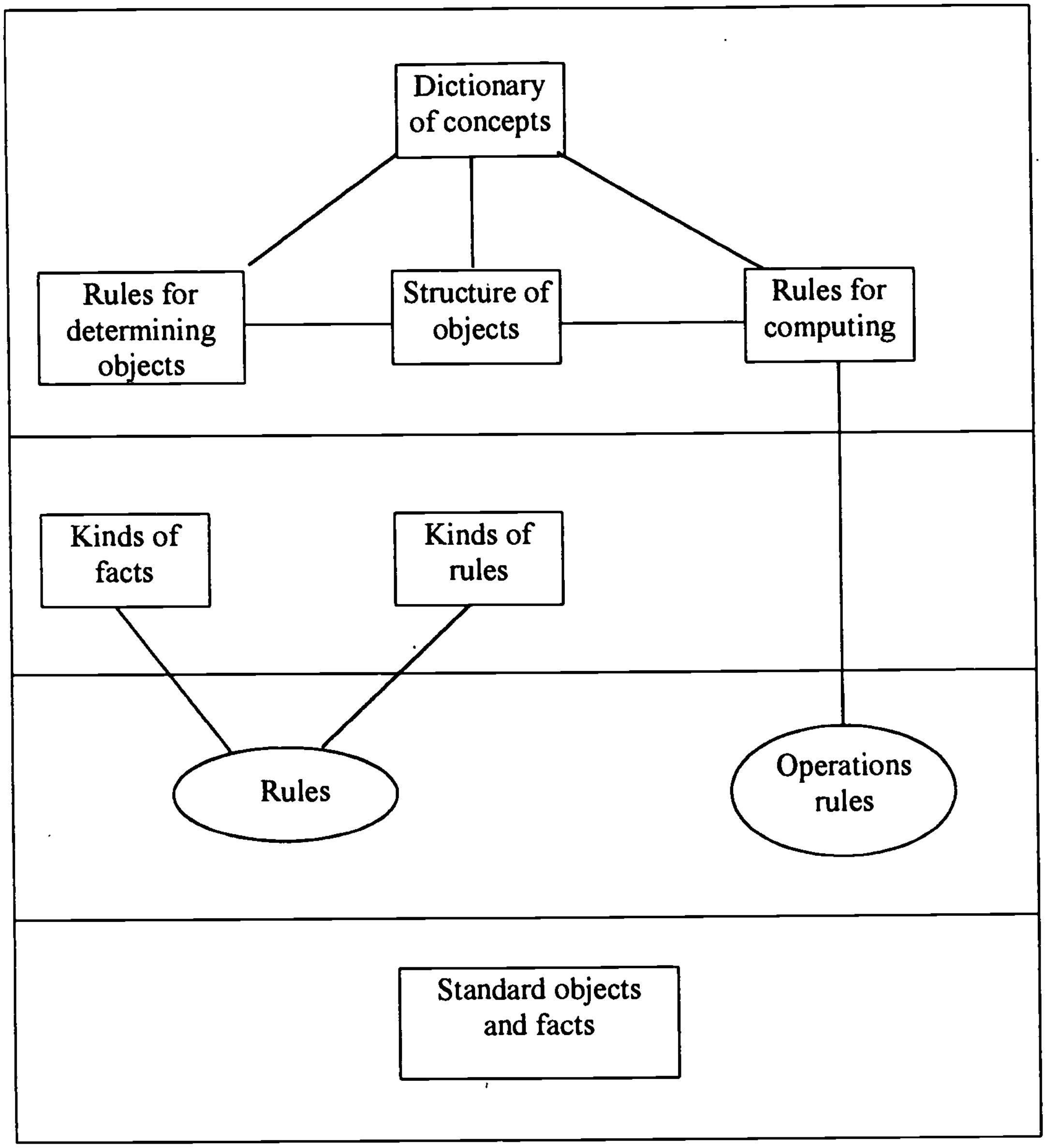
3.1.6 Table for descriptions of kinds of facts. For example, a relational fact consists of kind of the relation and the list of objects in the relation.

3.1.7 Table for descriptions of rules. For example, a deducible rule consists of hypothesis part and conclusion part. Both of them are the lists of facts.

3.1.8 The list of rules.

3.1.9 The list of standard objects and facts.

3.2. Diagram for classifying and the relation of the components.



4. Knowledge Base Access

By the organization of the knowledge base of 3-dimensional analytic geometry we can easily access the knowledge base of the system. Concepts, operations, facts and rules can be added or deleted.

For adding a new kind of objects we have to give the name, the attributes, the internal relations and features of objects. Besides, we may give some relations relative to another kind of objects and some rules.

In the case of adding a new operation, it has to be determined by the computing rules given and there may be another relative rules.

If we want to delete a concept, relations which have relationship with that concept must be deleted. Relative facts, operations and rules must also be deleted.

For the above comments about knowledge base we can draw a process of access the knowledge base.

5. Conclusion

Knowledge representation model proposed in this paper give us a natural way for representing knowledge. This is the base for constructing the knowledge base of the system that can solve exercises in the field of analytic geometry. We hope that our AG model will be researched and developed to become a useful tool for designing the knowledge part in knowledge systems.

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