

Automated Reasoning in ICAI

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How can the **AUTOMATED REASONING** be used to develop educational software? What would be the **EDUCATIONAL SOFTWARE** with Automated Reasoning? The intellectual educational software **SOLID GEOMETRY** (one of the series named **MATHEMATICIS LABORATORY**) may give us some insights to above questions.

For Teachers:

The software **SOLID GEOMETRY** can be used to prepare his lessons and to demonstrate the geometric illustrations in his classes.

For students:

It is a nice tool to help them to review and to be used in the learning activities.

You are invited to see its interface. (figure 1)

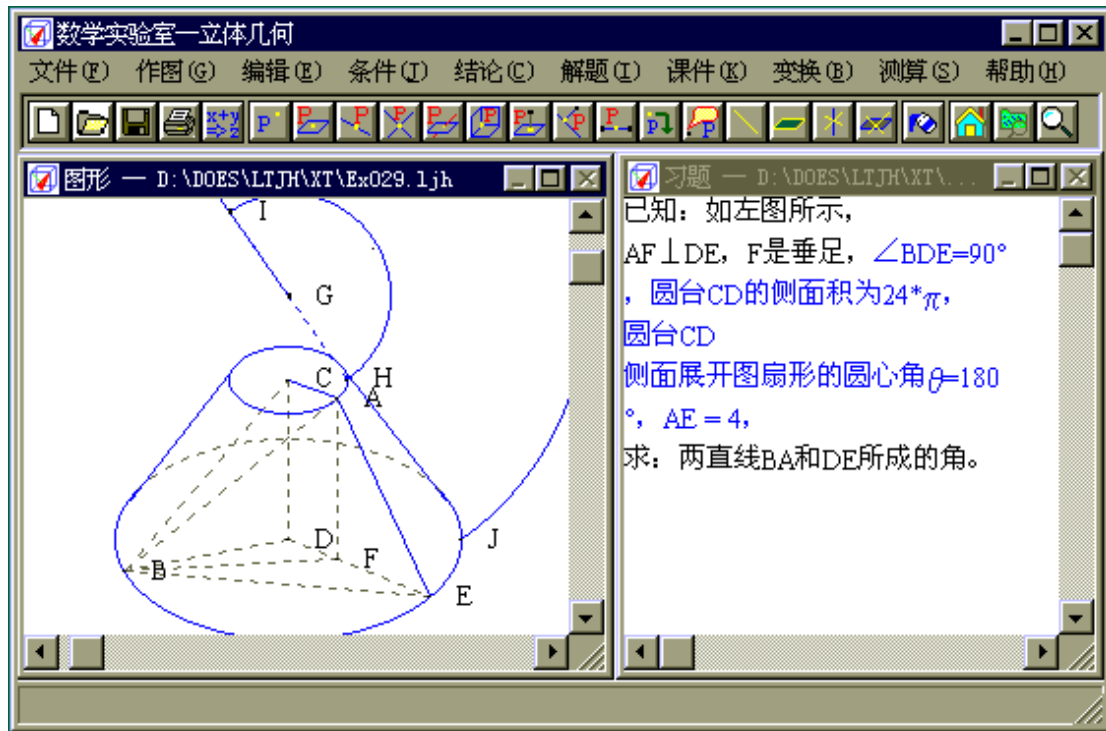


Figure 1.

FUNCTION 1 Dynamical Construction.

While you drag a free point with the mouse, the graph would change accordingly, but the graph still keeps the geometric properties you specified.

Computer will automatically remember the construction procedure. For example, while the user gives a series of instructions: "A is an arbitrary point of space", "M is the midpoint of line segment BC", "P is the common point of plane ABC and perpendicular of plane ABC through point E", the figures change dynamically. The system maintains the intelligence and the characteristics which they were instructed. For example, when we draw an arbitrary quadrilateral ABCD in space and take the midpoints E, F, G, H of four sides; then, dragging the point A (or B, C, D), the shape of quadrilateral and the position of the midpoints are changing instantly. However the midpoints will always stay as a midpoints. (See Figure 2)

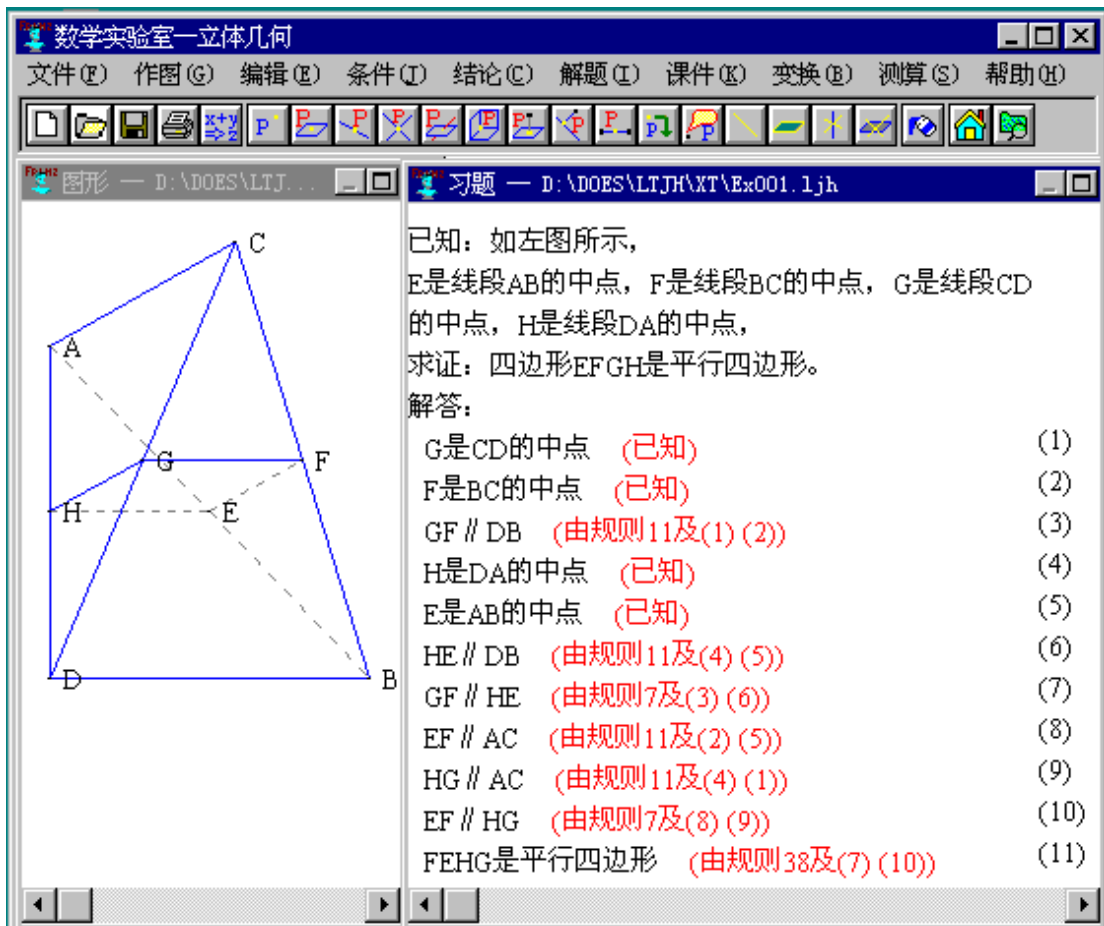


Figure 2.

FUNCTION 2. Generating Problems.

When a graph is constructed, we may add a condition or ask some geometry quantity be changed so that certain problems may be generated. Furthermore, you can add some geometry conditions to the presuppositions, such as: two angles are equal.

When the user discovers an interesting property from the figure, he may raise a conjecture. For example, for the figure above, one can raise the question such as "EFGH is a parallelogram" and form a geometry provable problem (Figure 2). At this stage, a teacher can formulate a numerical problem by asking students to calculate any geometrical quantity such as the length of a line segment or the degree of a dihedral angle.

For the example given above, suppose we want to add the condition, "let the two diagonals of quadrilateral AC, BD be perpendicular to each other", the hypothesis cannot be included in the figure conveniently during the construction; however, we can add the hypothesis with the menu. This hypothesis is reflected by a change of colors on the screen to show that it is imposed by the figure construction.

Therefore, this software system can interact with the users intelligently through the procedure of figure constructions, imposing hypothesis and suggest conclusion or calculating object instructed by the users.

FUNCTION 3. Automated Reasoning.

Based on the basic properties of the geometric figure and the additional conditions, a series of rules (axioms, definitions, theorems and formulae) are used by the system to find many other geometric properties of the graph from the problems imposed by users.

For example, let's draw a quadrilateral ABCD and take midpoints EFGH of four sides. The system will use "automated reasoning" to deduce that EFGH is a parallelogram. (Figure 2).

When the diagonals' lengths are set to equal to each other ($AC=BD$), the system will deduce further that EFGH is a rhombus.

We note that the procedure of "automated reasoning" is closely related to the figures chosen by users. If point D is between point A and B, then $AB=AD+BD$; otherwise, $AB=BD-AD$.

FUNCTION 4. Alternate Solving.

This software has another intelligent feature: if one inputs his reasoning for solving a problem step by step, the system will give comments on every step that is given by the user. User may dynamically choose facts from the information provided by computer as the presupposition. Then the computer does one step of reasoning based on the chosen facts, until the reasoning process is clear to the user.

Users can use this system as a self-learning tool by using the "Manual Solving" provided with the system. Specifically, when the user give reasoning step by step, the computer will determine if each step is logical. The system will add reasons for agreeing or disagreeing with the user.

The feature "Alternate Solving" is easier than "Manual Solving". For "Alternate Solving", users can choose one or more geometrical information which is supplied by the system. This includes known conditions and reasoned properties. The computer will either provide a further reason or it will make conclusions according to the new information for user choso (Figure 3).When the conclusion we want is reasoned, the computer will generate the proof along the line of reasoning of the user.

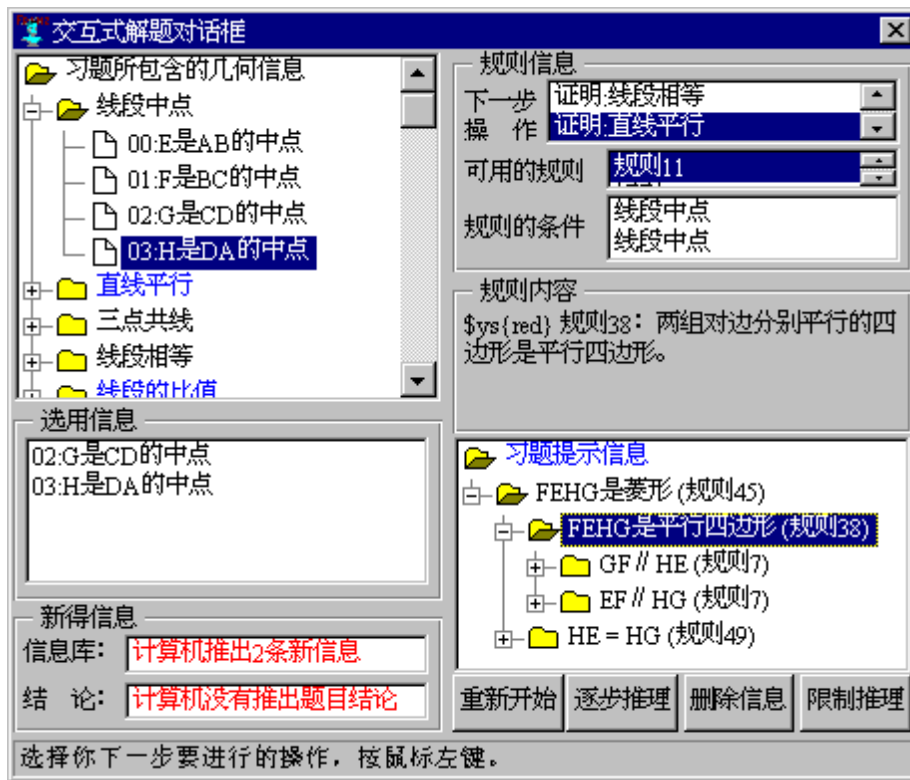


Figure 3.

FUNCTION 5 Measure in Space.

The computer can measure a solid geometry graph constructed by user to find the length of a segment, such as the degree of an angle, the area of a triangle, and the volume of a prism, etc. The scale of the ruler could be either fixed or dynamical. The data measured will change while the graph was changing.

For example, when a square ABCD is drawn through point A and a line AP is drawn perpendicular to plane ABC forming the pyramid P-ABCD, the user can measure the length of PA, PB and the degree of dihedral angle B-PC-D. The data in screen will be changed along with point P's moving. When PA=AB, the degree of dihedral angle B-PC-D is 120° (Figure 4). Then, we discover an interesting property. The computer will give its proof based on the function of reasoning.

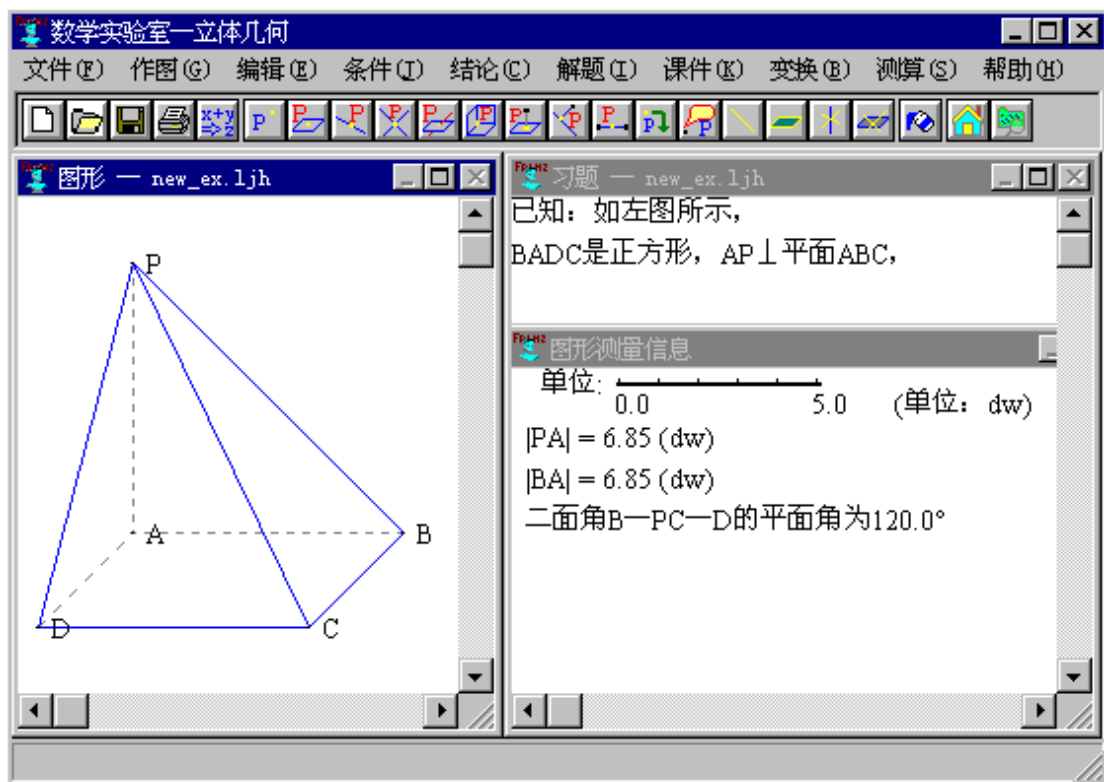
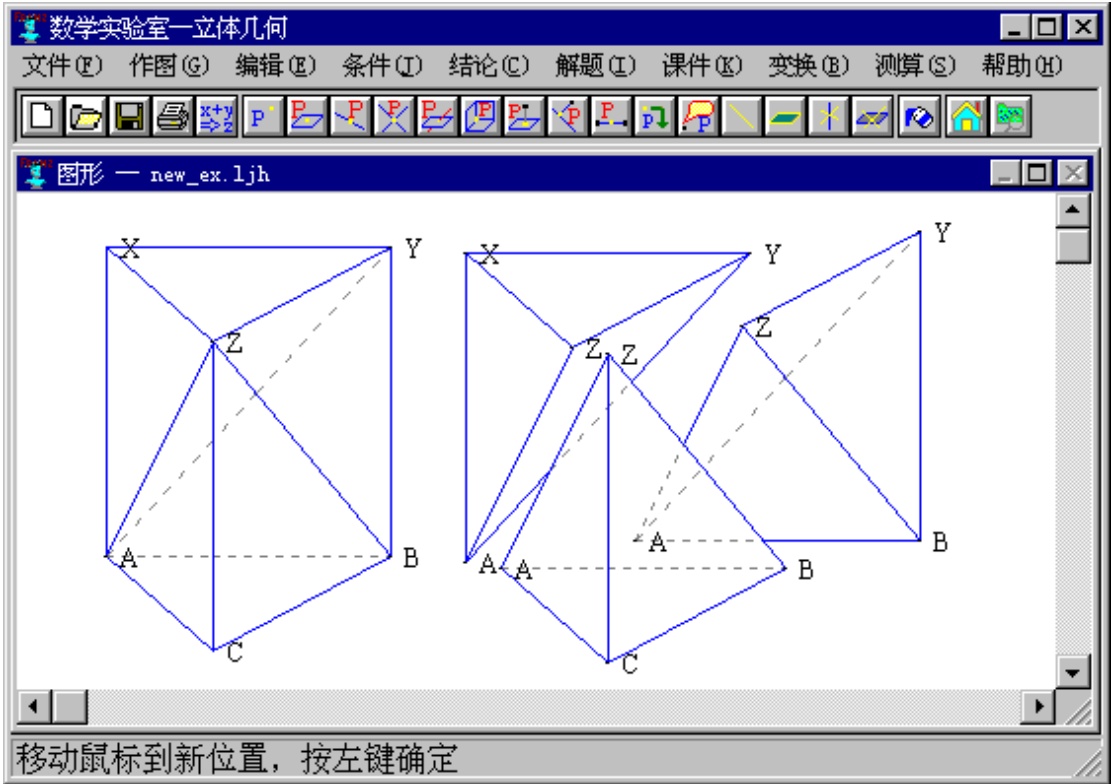


Figure 4.

FUNCTION 6 Partial Copying of Figure

Using this function, we can imitate the partition of a solid. For instance, we can draw a prism ABC-XYZ first, then copy three tetrahedrons AXYZ, ABCZ and ABYZ from this prism. And move them to return to the original shape using the **parallel moving** function. This way we can clearly explain the truth "Volume of

pyramid is equal to $\frac{1}{3}$ that of prism which with the same bottom and equal height" (Figure 5).



(Figure 5)

FUNCTION 7 Section of A Solid

User can cut prism, pyramid etc with arbitrary assigned plane. For example, we may construct the section of cube by cutting along the plane perpendicular to its main diagonal forming a regular hexagon. We can see its exact shape after rotating the cube to adequate position (Figure 6).

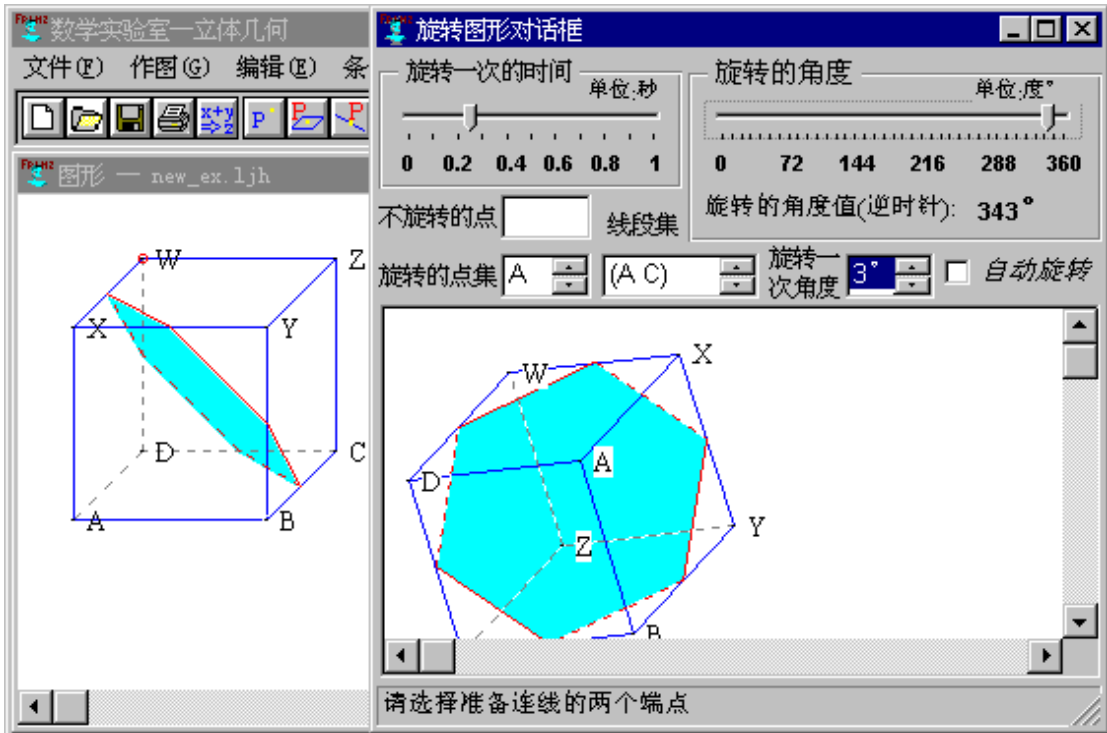


Figure 6.

The educational software based on automated reasoning, it can replace teacher to solve a lot of primary problems and have dynamical intuitional and alternate properties.

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