Object-Oriented Analysis of ELIMINO

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Abstract ELIMINO is a mathematical research system developed for the implementation of Wu's method, a powerful method for polynomial equation system solving and geometric theorem proving. The aim of ELIMINO is to provide user a programmable interpreting environment to use Wu's method in scientific research and engineering computation. In this paper, the development of ELIMINO system is outlined and the techniques adopted are discussed, then some details about the object-oriented analysis of ELIMINO are presented.

Keywords ELIMINO, Wu's method, characteristic method, mathematical research system, object-oriented analysis

1 Introduction

Computer algebra is a part of computer science which designs, analyzes, implements and applies algebraic algorithms\(^1\). Computer algebra was also called symbolic computation, since it manipulates mathematical expression in a symbolic way rather than numerical way. For symbolic computation, algebraic objects are expected to be represented exactly in the memory of a computer, so that algebraic computations can be performed without loss of precision. Since 1960s, many software systems that devoted to various class of symbolic computations have been developed. Major representatives of them are MACSYMA, REDUCE, MAPLE and MATHEMATICA. Although these sorts of systems are continuously increasing in efficiency and capacity, more powerful computer algebra software systems for special purpose are still needed. For example, the projects of POSSO and FRISCO in Europe, based on Gröbner basis method, are trying to create highly efficient, versatile polynomial solvers.

ELIMINO is an experimental mathematics mechanization research system developed in Mathematics Mechanization Research Center of Institute of Systems Science, Chinese Academy of Sciences\(^2\). It is a continuous effort that try to construct a software system of Wu’s method independent of any existing mathematical software system. Wu’s method\(^3,4\), also known as characteristic method, is a kind of mechanical method to manipulate polynomials and analyze the zero structures of polynomial equation system. The occurrence of Wu’s method not only opened a new epoch for mathematics mechanization, but also bring us a new method to manipulate polynomial equation system. The aim of ELIMINO is to implement the whole Wu’s method and provide users with a programmable interpreting environment to do polynomial manipulation or polynomial equation system solving by Wu’s characteristic set method.

As a mathematical research software, ELIMINO consists of three parts:

- **Kernel part**
  Kernel part is the soul of the system, it contains implementation of number system, polynomial manipulation system, characteristic set method. In fact, it is an algebraic computing engine. It provides various functions for using Wu’s method as polynomial processor.

- **Front-end**
  Front-end is the interface between the system and users, it accepts inputs from users, send it to the kernel and feedback to the user with processing results. ELIMINO’s
front-end provides friendly problem solving environment with an interactive interpreter and a programmable high level language.

- **Applications**

  Applications are packages or programs which are developed by using functions or libraries provided by ELIMINO such as polynomial system solver and geometry theorem prover, it may appears as build-in commands or external packages which can be loaded into the problem solving environment.

With above three parts, the system was divided into five layers as follows:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
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<tbody>
<tr>
<td>5th</td>
<td>User interface</td>
</tr>
<tr>
<td>4th</td>
<td>Application</td>
</tr>
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<td>3rd</td>
<td>Wu's method</td>
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<tr>
<td>2nd</td>
<td>Polynomial manipulation system</td>
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<tr>
<td>1st</td>
<td>Number system</td>
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</tbody>
</table>

Each layer is an independent module with explicit function to provide a collection of services that have close relations. The relations between layers are relatively slack. The system was build bottom-up, lower layers never call functions of upper one. Fig.1 illustrated the system architecture:

![Fig.1. System architecture of ELIMINO.](image-url)

The research and development of ELIMINO involves both mathematics and computer science. To expand and to improve the theory and methods of polynomial equation system solving is the goals to seek at any time, so the occurrence of any new method and new theory related to symbolic computation can help to perfect this system. In order to make the system be an open and flexible research platform, especially to be able to integrate new method or research achievements to the system, we have designed the software with opening architecture and reusable objects by using object-oriented technology\(^{[5,6]}\).

In the following sections, we will provide readers with more about the development of ELIMINO.