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Project

Computer-Generated Mathematics (CGM)

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The challenges of the project:

- Production of the first computer program able easily to discover new mathematical theorems.
- Production of the first computer-generated encyclopedia – The Computer-Generated Encyclopedia of Euclidean Geometry.
- Extension approximately 100 times of a branch of mathematics – Euclidean Geometry - by using a computer.

The aim of the project is the production of a computer program named the “Machine for Questions and Answers” (the “Machine”). The “Machine” is an on-line application accessible via Web browsers. The access is via passwords. The “Machine” is a discovery system, designed for school students and discovers scientific results (theorems) in the area of geometry in a form suitable for school students. The “Machine” will be able to produce approximately 10 millions theorems in Euclidean Geometry, that is, the users will be able to extend approximately 100 times the current Euclidean Geometry. The application works like Google. The user enters key words into a text field, or selects input words from a directory. As an output, the user will receive a list of the main theorems related to the keywords (like in Google, a number of options are available). The “Machine” produces also a new kind of theorems, which we could name “external theorems”. An “external theorem” is a theorem which the people cannot discover because of the limitations of the human brain. Also, the project includes production of the “Computer-Generated Encyclopedia of Euclidean Geometry” – the first encyclopedia all results in which are produced by a computer, and the “Journal of Computer-Generated Euclidean Geometry” – the first journal devoted to mathematics, created by computers. The “Machine” uses the English language. Translation to other languages is possible.

Progress of the project beyond the state of the art

"Within ten years a digital computer will discover and prove an important mathematical theorem." (Simon and Newel, 1958, Heuristic problem solving: The next advance in operations research. *Operations Research*, 6(1),1–10.).

This is the famous prediction by Simon and Newel. Now is 2008, 50 years later. The first computer program able easily to discover new deep mathematical theorems - The “Machine for Questions and Answers” (The “Machine”) has been created by the Principal Investigator of the project in 2006, that is, 48 years after the prediction. The first version of the “Machine”, created in 2006 is just a test version. The aim of this

version is to test the beginning of the ideas. Although relatively primitive, the first version of the “Machine” has discovered a few thousands new mathematical theorems, that is, approximately 90% of the new mathematical computer-generated theorems since the prediction by Simon and Newel. In 2006, the first version of the “Machine” has produced the first computer-generated encyclopedia, the “Computer-Generated Encyclopedia of Euclidean Geometry”, first edition. The first edition of the encyclopedia is just a test edition.

Computer algebra systems like Maple, Mathematica, GAP, etc. do not have the ability to discover new mathematical theorems. Mathematical provers like Isabelle (Prof. Lawrence Paulson, University of Cambridge, and Prof. Tobias Nipkow, Technical University of Munich) do not discover new theorems. The programs created by Douglas Lenat (Austin, USA) have not discovered till now a new math theorem. The main research centers in Europe, like Cambridge and Oxford (UK), Aachen and Munich (Germany), Research Institute for Symbolic Computation (Austria) have not produced till now a new mathematical theorem, discovered by a computer. In the European Union during the last 3 years there is no a new mathematical theorem, discovered by a computer (clearly, except for by the “Machine”). We have to notice a number of papers, books, conferences, projects, computer programs, etc. on discovery systems, e.g. the ten international conferences “Discovery Systems”, the discovery systems produced by SAP, etc. All this production does not ensure an effectively working computer program. Hence, we can conclude that the “Machine” is the first computer program able easily to discover new scientific knowledge. Clearly, the approach of the “Machine” is different from the other approaches. (Otherwise the “Machine” will not be able to work).

Introduction

There are a few advantages in using computers for discovering of new scientific knowledge. The main advantages are as follows:

- Computers could conduct scientific research at a deep level. The abilities of the people are limited. In fact, many directions and results in the science are not accessible to the people just because of the limitations of the people’s thinking. The approach of the project will remove this limitation.
- Computers could conduct scientific research faster than people. The approach of the project ensures that the computers could discover for a few seconds scientific facts for which the people will need a few years to be discovered.
- Computers do not need salaries. The approach of the project ensures that the scientific knowledge produced by the computers is many times cheaper than the knowledge, produced by the people.
- People make errors, but the computers do not make errors.

The project introduces a new approach to computer-generated knowledge. The approach of the project gives the base of a new industry – the industry of the knowledge produced by computers.

Preliminary work on the project

Links:

www.dekovsoft.com/ddekov/ - Personal site

www.dekovsoft.com/j/ - Journal of Computer-Generated Euclidean Geometry

www.dekovsoft.com/e1/ - Encyclopedia of Computer-Generated Euclidean Geometry, First Edition, September 2006.

Products of the project

Product 1 – Discovery system named the “Machine”

The main product of the project is the second version of the “Machine”. The second version of the “Machine” is produced by using new software tools, including new programming language and new database. These new software tools enable the power of the “Machine” to be realized.

Product 2 – Computer-Generated Encyclopedia of Euclidean Geometry

The encyclopedia contains selected results created by the “Machine”. The encyclopedia is designed as an extended textbook for school students. Planned editions – a freely accessible on-line HTML edition, and an edition as an e-Book for Windows. The encyclopedia will contain approximately 200,000 theorems – the 100,000 main known theorems plus approximately 100,000 new valuable theorems, discovered by a computer.

Product 3 – Journal

The journal of the project – the “Journal of Computer-Generated Euclidean Geometry” has to serve as a forum for discussions on the computer-generated results. The journal is freely accessible. The journal will publish also applications of the new results, comments to the new results, other (human) proofs of the new results. The journal will help to be clarified whether a computer-generated result is really new. The journal will help to the school students to improve their education. The journal will organize the first competitions between people and computers in the area of science –competitions between school students and computers.

Product 4 –Translations

The architecture of the available “Machine for Questions and Answers” allows easy translation from English language to other language. It is enough a list of terms and statements to be once translated.

The main goals of the project

1. Pedagogical use of the Machine

The Machine could be useful for students and teachers mainly in these directions:

1. The “Machine” will give to the school students and teachers the possibility to discover new theorems. The school students could combine the study of school notions and theorems with discovery of new theorems. By this way the schools will be able to realize a new method for studying - "studying by discoveries".
2. The “Machine” will produce an encyclopedia of Euclidean geometry suitable for school students and teachers. Also, the students and schools could produce their own encyclopedias (provided the creator – the “Machine” is quoted).
3. The interactive use of the “Machine” will give to the school students and teachers the possibility to investigate in depth selected problems. The students and teachers will be able to produce research papers for recognized mathematical journals (provided the creator – the “Machine” is quoted). Also, a school (university) could publish their own journal containing the most valuable results produced by the students (provided the creator – the “Machine” is quoted).
4. The “Machine” will give to the teachers the possibility easily to produce problems and theorems for textbooks, for use in the classroom, for home works, etc.
5. The “Machine” will give to the school students and teachers the possibility better to understand the abilities of computers to discover new scientific results. Such an understanding is important for the improvement of the education.
6. The “Machine” could be used for organization of competitions between school students and computers in the area of science - the first competitions between people and computers in the area of science. Like the olympiads, the competitions could be organized in a few levels - first in a single school, then in a state (province), and finally in the country.

2. Scientific Achievements

The project has to compare the abilities of the people and the computers and to prove that

1. The computers produce more large theory.
2. The computers produce more deep theory.
3. The computers are able to produce results which the people cannot produce because of the limitations of the human brain.

3. The objective area of the project

The project has to extend the Euclidean geometry so that the new theory has to be an essential improvement of the old one.

4. Competitions

The competitions between computers in the area of the game chess are well known. I would be glad to introduce competitions between discovery systems in an area of science, but the “Machine” is the only working discovery system in the world by

now. Douglas Lenat in the USA announced the discovery system “Automated Mathematician”, but the Lenat’s discovery system does not work – it has not produced by now even one new mathematical theorem. The other attempts in the area of discovery systems are failures, too. If someone thinks that his/her discovery system is able to compete with the “Machine”, please let me know. Nevertheless, I hope that soon we will be able to see competitions between two “Machines”, as the beginning of the competitions between discovery systems.

Competitions between people and the “Machine” are possible, but just as a show, or as a part of a program for improvement of education. In such a competition we have to use just a small part of the abilities of the “Machine”, otherwise the superiority of the “Machine” over the people will make the competitions non-sense.

5. Discovery systems – the beginning of the story

The advancement of a scientific area in the future will be identified with the work of a discovery system in the area. The discovery system, produced within the project, is the first discovery system, and it has to serve as a prototype for the future discovery systems in other areas. finance, accounting, engineering, marketing, auditing, law, procurement and contracting, project management, risk assessment, information management, information retrieval, crisis management, stock trading, strategic management, network management, telecommunications, space education, intelligent front ends, intelligent database management systems, physics, biology, medicine, chemistry, human resources management, human capital, business, production management, archaeology, economics, energy, and defense.

For example, in the “constructive biology”, the “Machine” will produce artificial live organisms with desired properties. For example, the “Machine” could produce bacteria which transform cheap materials to oil. The approach of the “external results” here could be very important. Also, the ability of the “Machine” to produce the optimum results with unlimited quality (since the quality could be ordered in advance) here could be important. Such an application could improve in a radical way the world’s economics.