Call for Contributions to the ISAC-Project

by Master Projects, project/seminars, Baccalaureate Projects

Promotion of an upcoming generation of math assistants is the aim of the ISAC-Project at several Austrian universities: the upcoming generation will be based on Theorem-Prover (TP) technology and it will have features appealing for education:

1. *all* underlying mathematics knowledge is human readable (and *not* some program code), see `http://isabelle.in.tum.de/dist/library/HOL/Rings.html` for knowledge of Isabelle used by ISAC.
2. TP-based math assistants cover the *whole* range of problem solving: from the specification to the final (and automated!) proof of the post-condition.
3. Because of the coverage, TP-based assistants can model *stepwise* problem solving — steps input by the student establish proof situations *automatically* checked by TP.
4. Combination of deduction and computation provides "next-step-guidance", the system can suggest a next step if the student gets stuck.

These features lead to flexible systems which will advance into science education. For instance, Figure 1[1] shows a problem solution of an engineer for a Z Transform in Signalprocessing, and Figure 2 on p.2 shows the same calculation in stepwise constructing a partial fraction decomposition.

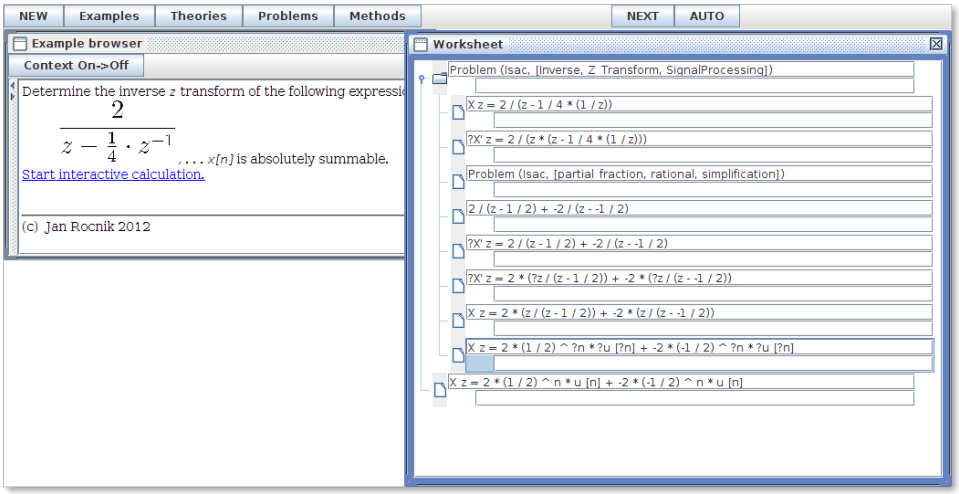

Figure 1: Focus on engineering (inverse Z Transform)

The advantages of TP-based math assistants are flexible adaption to various ways in stepwise calculation and immediate feedback. Austrian universities develop a prototype, called ISAC[2], of such an assistant. This prototype shall be used in science and technology education.

[1] see http://www.ist.tugraz.at/isac/index.php/Development_Computer_Mathematics for better images.
[2] http://www.ist.tugraz.at/isac/index.php/Main_Page and http://www.ist.tugraz.at/projects/isac/

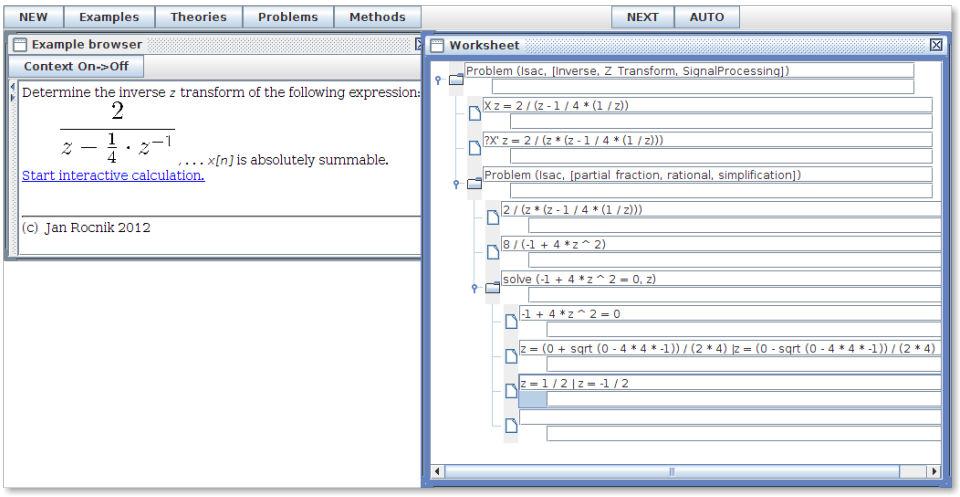

Figure 2: Focus on mathematics (partial fraction decomposition)

The following topics address mathematics students; the topics aim at extension of ISAC's transparent knowledge (Pt.1 above) with basic algorithms of symbolic computation; prerequisites are interest in functional programming (we use Standard ML) and in TP technology:

Algebraic simplification for various domains is a basic feature in Computer Algebra and in engineering applications, which actually "simplifies" terms:

$$\frac{2*a+3*b}{b*c} + \frac{3*c+a}{a*c} - \frac{2*a^2+3*b*c}{a*b*c} = \frac{4}{c}$$

ISAC's simplifier already works partially for integer terms and rational terms, cancellation of multivariate polynomials is under construction at RISC already.

The goal of this task is to embed cancellation into ISAC's simplifier, to extend the simplifier to complex numbers and to develop specific simplifiers for the equation solver.

Equation solving is another basic feature known from Computer Algebra; in a TP environment, however, more precision is requested: we want to be sure to get *all* solutions of an equation. And equation solving shall be re-engineered for stepwise construction of solutions.

ISAC can solve some specific equations presently. The goal of this task is to generalise ISAC's equation solver to all elementary univariate equations over the reals and to univariate equations over complex terms.

Integration for single stepping systems: Integration, as the "inverse problem" of differentiation, has evolved to general algorithms which immediately switch to complex fields; these algorithms are implemented in Computer Algebra as black boxes.

This task will open these black boxes for educational purposes; thus the first collection of respective algorithms shall be as elementary as possible. Elementary algorithms, however, are not that general; so this task will arrange the algorithms in a hierarchy of integral types, which can be used for automated refinement analogous to ISAC's equation solver.

Interested ?

More info at http://www.ist.tugraz.at/isac/index.php/Development_Computer_Mathematics.

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