jSFTools — Knowledge Based System on Special Functions: Java version

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Abstract. The software package jSFTools is presented. It allows to handle in Internet symbolic and numeric information related to knowledge on special function of mathematical physics. The previous system jSFtools was developed as a stand-alone version and was presented on CASC 1998. The major changes are: use of Java Applications instead of Delphi as an instrumental tool and IBM DB2 instead of Paradox as the database. The project was realized as portlets on IBM WebSphere Portal Server.

Few years ago the software package SFTools — Knowledge Based System on Special Functions — had been developed. It allowed to find necessary for the user information about special functions, insert it as latex code in mathematical text and produce some calculations like finding eigenvalues originated by the corresponding equations. It was arranged as a Delphi-coded dialogue stand-alone knowledge based system. The information about the system was presented at the conferences CASC-98 [1], IMACS-ACA-2000 [2] and other [3, 4]. As a better source of information for the mathematical background and particular classification which determined the structure of the database the book by S. Slavyanov and W. Lay [5] and the doctor thesis by A.B. Pirozhnikov [6] can be used. The earlier exposition of basic ideas concerning the database can be found in paper [7].

Later on several attempts have been made to develop an Internet version of SFTools. This paper presents the latest version — the system jSFTools. It is installed on the IBM WebSphere Portal Server as a package of portlets and servlets implemented using Java2 technologies. The database IBM DB2 is used for storing the data (in SFTools it was Paradox). jSFTools can be accessed at the Internet address: www.spbu.ru/wps/portal/mathphys (w3.spbu.ru:9081/wps/portal/mathphys).

The mathematical structure of the system is explained in details in the above-mentioned publications. It is related rather to general analytical theory of linear ODEs (ordinary differential equations) than to historical notions and background. This makes the system nontraditional and in this respect different from NIST project based on Abramovitz and Stegun handbook on special functions [8]. We want to stress that the latter project is not accomplished yet although it has been announced more than five years ago and has been developed by several working groups in different countries. It shows the difficulties in handling symbolic information in Internet if it is not based on tools like HTML.

The following classes of special functions are presented in the system:

1) hypergeometric-type functions,
2) Heun functions,
3) Painleve transcendents,
4) orthogonal polynomials.

For these functions basic differential equations with emphasize to singularities, integral relations, Frobenius expansions in the vicinity of regular singularities, Riemann's P-symbols and other important characteristics are given. Output in TEX format is available. In several cases the numerical values of eigenvalues can be computed by Jaffe-Lay algorithm. This algorithm transforms explicitly the differential equation to a difference equation where the structure of solutions according to their asymptotics is of major importance.

In order to configure the information the processes of confluence and reduction of equations are widely used. By confluence we mean some limiting processes including both the independent variable and parameters of the equation. The corresponding limits are exposed in the system. Five different equations are distinguished in the hypergeometric class, ten equations in the Heun class, and nine equations in the Painleve class. The orthogonal polynomials are classified according to Askey-Wilson scheme modified by R. Koekoek and R. Swarttouw [9]. The weight function for the orthogonalization condition, the normalization, recurrence relations and the presentation in terms of generalized hypergeometric function are given.

Four major windows of the interface of jSFTools contain buttons arranged in a hierarchical tree-type structure. By striking with a mouse on this button the user opens a window with formulae corresponding to special function arising as solutions of the chosen particular type of equation. On a physical level the servlet installed on the Portal Server selects the needed formula from the data base and sends it to the client computer as a picture or HTML file. There it is mapped on the display by any browser. Each formula can be enlarged and standard output as tex-type text is foreseen. Also help system which gives useful information is available. An example of jSFTools window is given on Fig. 1.

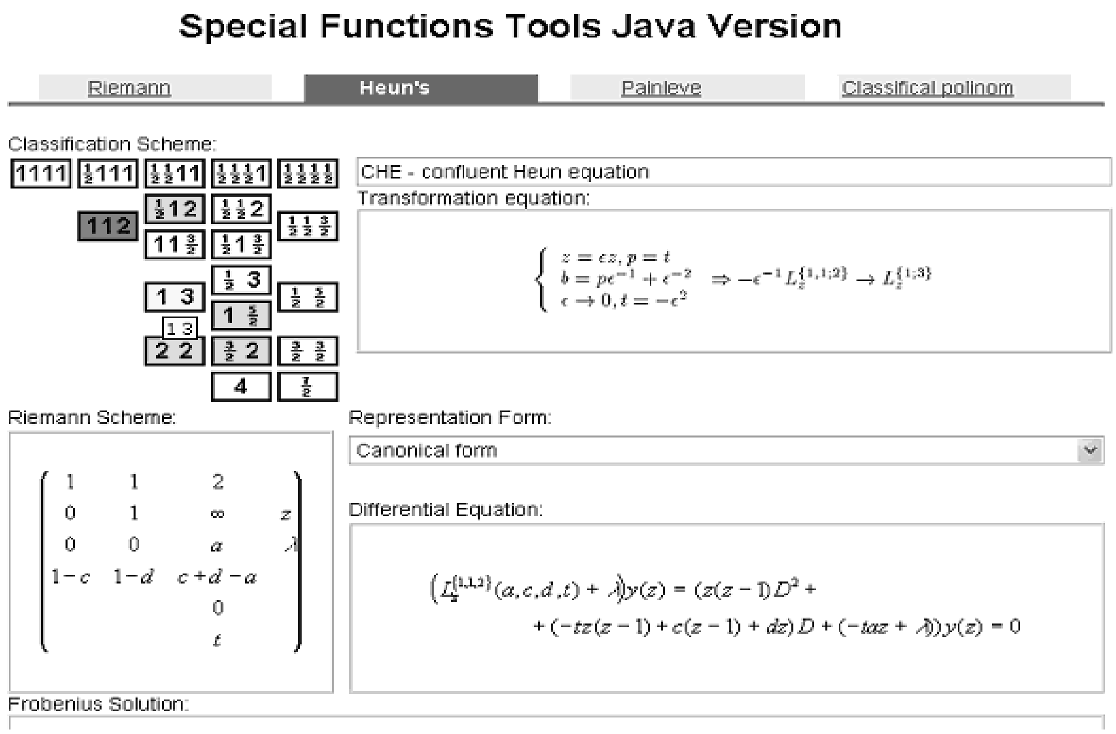

Fig. 1. Second major window with Heun functions

WebSphere Portal Server is one of the leaders on the market of platforms for Internet portals. It permits to integrate the information without dependence on a hardware platform. It supports the J2EE standard (Java2 Enterprise Edition) and allows execution of JSP (Java Server Pages), servlets and portlets. J2EE assists to maintain the portability of applications ("write once, run anywhere"), to achieve security in Internet, to support the Enterprise Java Beans, Java servlets API and Java Server Pages. IBM WebSphere Application Developer was chosen as a developing tool.

jSFTools is implemented as the web application consisting of one portlet and two servlets with the Enterprise Java Beans technology. HTML 4 and CSS (Cascading Style Sheets) were used while coding HTML pages. The use of CSS permits to change easily the visual characteristics of the system without disturbing major program modules.

The system jSFTools was developed under following requirements.

1) The user is not supposed to have deep knowledge in computer science.
2) The system is intended to provide the means to modify the stored information without changes in the user interface.
3) Access to external instrumental tools like text editors should be provided.

The database IBM DB2 provides the information stored in jSFTools. Access to the database is established by the driver JDBC which serves as an Java applied program interface (API).

The following items are supposed to be the future extensions of the system:

1) Transition to MATH ML format.
2) Inclusion of functions arising as solutions of linear difference equations (gamma-function and beta-function, for instance).
3) More flexible instrumental tools for modifications in the database.

The jSFTools system is not the system of Computer Algebra if we mean the use of algebraic transformation but is the system of Computer Algebra in a broader sense while it allows to handle the symbolic data as elements of database in Internet with further numeric or algebraic processing.

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References

1. Slavyanov, S.Yu., Lay, W., Akopyan, A.M., Pirozhnikov, A.B., Dmitriev, V.Yu., Yazik, A.B., Zhegunov, V. Knowledge Base on Special Functions. Zap. Nauchn. Sem. PDMI **258** (1999) 345 - 354
2. Pirozhnikov, A.B. SFTools - Knowledge Based and Educational System on Special Functions, Int. Conf. "IMACS-ACA-2000", St Petersburg (2000)
3. Slavyanov, S.Yu., Akopyan, A.M., Lay, W., Pirozhnikov, A.B., Zhegunov, V. How to handle special functions on a computer, Int. Conf." Forschungsforum 97", Leipzig, Germany (1997)
4. Glebovsky, A., Kuleshov, A., Petrov, A., Pirozhnikov, A., Slavyanov, S. REXAM: a unified remote tools for distributed authoring management and use of knowledge tests in distant learning courses over the Internet, Int. Conf. "Conceptual Learning of Science", SPbSTU, St Petersburg (1999)
5. Slavyanov, S.Yu., Lay, W., Special functions: Unified Theory based on Singularities. Oxford, Oxford University Press (2000), Russian edition: St Petersburg, Nevskii Dialect (2002)
6. Pirozhnikov, A.B. Doctoral thesis. St Petersburg (2000)
7. Slavyanov, S.Yu., Zolotarev, V.I. Principles of organization of a Knowledge base on Special Functions, Vestnik SPbSU, ser. mat. (1993), in Russian
8. Abramovitz, M., Stegun, I. Handbook of Mathematical Functions, Applied Mathematics Series. Vol. 55. NBST (1964)
9. Koekoek, R., Swarttouw, R. The Askey-scheme of hypergeometric orthogonal polynomials and its q-analogue. Delft Univ. of Technology. Netherlands (1994)