DETECTION OF NEAR DUBLICATES IN TABLES BASED ON THE LOCALITY-SENSITIVE HASHING METHOD AND THE NEAREST NEIGHBOR METHOD (p. 4-10)

Petro Lizunov, Andrii Biloshchytskyi, Alexander Kuchansky, Svitlana Biloshchytska, Larysa Chala

A hybrid method for the detection of near duplicates in tables is proposed.

This method allows the identification of similarities between text and numeric data of tables separately, and then it generalized the results obtained. For the text data, sequences of words are formed in the canonized form, from which, based on the method of locality-sensitive hashing, the bit sequences are constructed. A similarity between data in this case is determined by the Hamming distance at the assigned threshold value. The identification of similarities between numeric data in tables is implemented based on the method of the nearest neighbours with assigned metric distances. The method makes it possible to identify near duplicates, present in data in the input table, relative to a set of tables, which are selected from the scientific publications and dissertations and theses papers. It should be noted that the method is designed for finding near duplicates in tables that contain only text and numeric data. In the case of availability in the content of examined tables of pictures and formulas, these objects are examined separately by using specific methods.

The method proposed might be implemented in the systems that are intended for running intelligent analysis of information represented by text and tables to identify similarities and detect near-duplicates, in particular, antiplagiarism-systems.

Keywords: near duplicate, similarity, locality-sensitive hashing method, nearest neighbor method.

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DEVELOPING OF MULTI-FACTOR AUTHENTICATION METHOD BASED ON NIEDERREITER-MCELIECE MODIFIED CRYPTO-CODE SYSTEM (p. 11-23)

Serhii Yevseiev, Hryhorii Kots, Yehor Liekariev

Two-factor authentication methods to date; are considered by experts as authenticators resistance amplification mechanisms, while ensuring the authenticity services in various fields of high technology, financial and insurance sectors of the market, large banking institutions and public sector enterprises. Thus, authenticators based on OTP passwords and various types of tokens are typically used in the ABS. The suggested synergistic threat assessment approach revealed that attackers use a comprehensive approach to the implementation of threats, based on a combination of social engineering techniques with traditional methods; of disguise and infiltration. New types of cyber-attacks are also used to effectively embed malware on mobile communication devices, which in turn leads to a decrease in the profitability of the two-factor authentication methods based on SMS messages and OTP passwords in ABS. The proposed safety mechanisms based on modified crypto code Niederreiter and Mc-Eliece systems allow to ensure reliability (based on the use of elliptical error-correcting codes) and safety (proposed cryptosystem are secret models of

provable resistance) of data transmitted. Their usage in the multi-factor authentication protocol ensures the security of the physical separation of transmission of the parts of authenticator of banking transactions through mobile lines (using the Niederreiter MCCS) and ABS (using the McEliece MCCS). The proposed mathematical model and algorithms of practical implementation of the Niederreiter MCCS allow, based on the error vector symbol shortening, to reduce the energy capacity of the group operations, reduce the power of the Galois field to GF 2^6–2^7, providing the required cryptographic resistance.

Keywords: modified crypto-code system, modified algebrogeometric codes, multi-factor authentication.

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ON IDENTIFYING THE FORMATION PRESSURE AND FILTRATION COEFFICIENTS OF TWO GAZ-BEARING FORMATIONS (p. 24-35)

Anatolii Markovskii

In the practice of gas field exploitation, there arises a problem of the production rates calculation for two gas-bearing formations opened by a single well. Its solution requires knowledge of the formation pressures and flow coefficients. While solving the problem, an important concept of the turning points has been introduced. They play a key role in developing a system of equations. In practice, no information on the formation flow coefficients and pressures is available; therefore, a question now arises of how they can be determined. It is possible to use downhole measurements, although doing this appears to be technically challenging. Wellhead measurements are simpler, but they provide only total production rate values under a fixed wellhead pressure. In [9], the authors are of the opinion that "measuring the flow coefficients of two gas-bearing formations opened by a single well without downhole measurements is currently impossible."

The problem under studying may have 13 different variants of setting up, depending on the placement of the wellhead pressure that is measured with respect to the turning points. It is unknown in advance which of the aforementioned variants is the case while measuring; therefore, it is necessary to study each of them individually. One of the most difficult cases is considered in the present article. Mathematically, the problem is reduced to solving a system of equations with 30 unknown quantities, and only 6 out of these equations are linear. Among the unknowns, there are the formation pressure and flow coefficients 3+3=6 of the upper and lower formations as well as 24 unknowns at each formation flow rate measuring: 6+6=12 and 6+6=12 wellbore pressures.

It is reasonable to take the upper formation flow rates as the main unknowns in 1, 3, and 5 measurements, in which case the unknown formation pressures and flow coefficients are determined: they turn out to be the functions of the main unknowns, which in their turn satisfy a system of a three nonlinear equations' polynomial over the first unknown of the seventh degree. Therewith, it is shown that two other main parameters are changed within the bounded domain, the boundary of which is explicitly described. This fact significantly simplifies solving the problem, whereas the desired formation pressures and filtration coefficients are a priori unbounded.

Keywords: gas filtration, real gas factor, two gas-bearing strata, well production rate, formation flow rates, turning points, Newton's method.

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DEVELOPING AN ALGORITHM WITH IMPROVED RELEVANCE FOR THE LOCALIZATION OF VECTOR'S COORDINATES FOR INTELLIGENT SENSORS (p. 36-44)

Tetyana Marusenkova

There are sensors of vector quantities whose field characteristics are described by the equations of quadrics. These sensors have improved sensitivity and smaller dimensions, the "payment" for which is, in fact, the non-linearity of field characteristics. In order to use such sensors, one has to solve the system of three quadric equations. Given the labor-intensity of this process, the sensors are designed intelligent – a finished device includes microcontrollers or other units that are able to process results of measurements. These devices are characterized by "curtailed" software and hardware capacities that necessitate the development of algorithms and their implementations with regard to these constraints.

Classic algorithms for solving the systems of polynomial equations are not appropriate because of their violating the requirements to minimal resource consumption. The search for solutions of the systems of quadric equations is carried out in two stages – first, numerical fields that potentially contain intersections are localized, and then in these regions the search is conducted for accurate solutions by numerical methods. The success of using numerical methods depends on the quality of the conducted localization of solutions. The means of localization are not sufficiently worked out. Earlier, an algorithm was developed using interval arithmetic, the implementation of which by a microcontroller of the ARM Cortex-M4 architecture proved its capacity to find all, without exception, regions with the sought solutions of a system of equations, however, in addition to the "useful" regions, this algorithm finds as well the regions that do not actually contain the solutions. This fact led to unnecessary waste of time trying to find exact solutions in the regions where they do not exist.

Thus, there was a need to search for alternative ways to the localization of solutions for the systems of quadrics equations. It is natural to search for these methods, based on the properties of quadrics in particular and continuous differentiable functions in general. A foundation of the proposed algorithm is the fact that a function in a closed region acquires its maximum or minimum value either at the borders or in critical points. If we accept, as a closed region, a rectangular parallelepiped, then its boundaries are its six sides, the boundaries of sides are its edges, and the boundaries of edges are the tops of parallelepiped. On the sides of the parallelepiped, function of three variables is reduced to function of two variables, on the edges – to functions of one variable. In the case of quadrics, finding the critical points of function on the edges comes down to solving a linear equation, and the critical points of function on the sides – to solving a system of two linear equations with two unknowns. Therefore, it is sufficient to check the signs of function at the tops of rectangular parallelepiped and those critical points of function that belong to the examined region. If in all these points the signs of function are the same, then there is no any point inside where function takes the 0 value. Thus, checking the signs of all functions that represent the left parts of the quadrics equation allows us to "reject" the regions, where there possible may not be any points of intersection. Instead of remembering the values of functions (valid numbers), it is sufficient to keep the signs of functions (one bit), which provides for the less consumption of operative memory. The tests proved that the proposed new algorithm is applicable for the implementation in the micro programming software, thus providing for a higher relevance of the found regions in comparison with the algorithm-analogue. An increase in relevancy is explained by the fact that interval arithmetic always implies overstated evaluations because, as the lower boundaries of intervals, the minimum permissible values are accepted, and as the upper limits – maximum permissible values. Checking the signs of functions in the selected points is free from the revaluation of results. The new algorithm somewhat deteriorated performance of permanent memory and execution time, however, these costs are compensated for by the further search for the solutions for a smaller number of irrelevant regions.

Keywords: intelligent sensors of vector quantities, localization of quadrics intersection points, ARM microcontroller.

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CONSTRUCTION OF OPTIMAL WIRE SENSOR NETWORK FOR THE AREA OF COMPLEX SHAPE (p. 45-53)

Oleksiy Antoshkin, Alexander Pankratov

The study is devoted to the problem of designing wire sensory networks for the areas of arbitrary shape. The problem is posed as the construction of the optimum coverage of an area with circles of the equal radii, connected by routes. The purpose is to reduce the total cost of the construction of sensory network to minimum. For developing the effective algorithms in this field, it is necessary to construct the mathematical models, which are based on analytical description of relationships between the objects. The coverage restrictions are described in the work with the help of the phi-functions free from radicals and the new class of functions of belonging of points to areas. For modeling different relationships between the objects we proposed: pseudonormalized functions of belonging of points to areas, functions of quasi-belonging of points to areas, normalized functions of quasi-belonging of points to areas and pseudonormalized functions of quasi-belonging of points to areas. The mathematical model, constructed with the application of new means of modeling, is in the general case the problem of the non-smooth optimization. The strategy of the solution, which includes the algorithm for generation of starting points from the area of permissible solutions of the problem and the optimization procedure, is proposed. Starting points are constructed with the help of heuristic methods. The construction of the starting point includes the stage of the construction of circular coverage and the stage of trace routing. The procedure of the search for the local extrema, which reduces the problem of non-smooth optimization to the sequence of problems of nonlinear programming, was proposed. As a result of the conducted study, the approach, which makes it possible to use contemporary NLP-solvers in the search for the local-optimum solutions of the joint problem of circular coverage and trace routing of wire connections, was proposed. The proposed approach can be easily adapted to solving other problems of covering areas with identical circles. In particular, the problem of the minimization of radii of covering circles for areas with the curvilinear boundary was solved.

Keywords: circular coverage, area of complex shape, trace routing, means of modeling, construction of mathematical model, nonlinear optimization.

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FUZZY MODELS OF ROUGH MATHEMATICS
(p. 53-60)

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The study shows that the introduced known formal description of rough sets can be interpreted in terms of fuzzy sets. This makes it possible to solve many problems of rough mathematics by the developed apparatus of fuzzy mathematics. The authors suggest a way of describing rough numbers with the help of membership functions of fuzzy numbers. The study specifies the chosen type of membership functions and the method of calculating their parameters. The algebra of fuzzy numbers is adapted to perform operations with numbers that are described roughly. The obtained elements are formulae for calculating the expected values and variations of rough numbers. These correlations are simplified for the most realistic special cases. A possibility is considered for solving roughly given optimization problems. A procedure is described for reducing an optimization problem with rough parameters to a usual problem of mathematical programming. An example is given on solving a linear programming problem whose parameters are determined roughly. The rough problem parameters are described with functions of an (L-R) type. It is suggested that the problem should be solved on the basis of the introduced complex criterion. The numerical value of the criterion takes into account the extent of closeness of the obtained result to the modal solution as well as the level of compactness of the membership function of the resulting value of the objective function.

Keywords: rough mathematics, fuzzy models of rough numbers, problem solving in rough mathematics, rough linear programming.

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