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Numerical modelling of viscous incompressible flow [Abstract of thesis]

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is to obtain a highly effective method of numerical integration of some particular classes of functions whose ranges are split into two parts with essentially different complexities, e.g. peak functions etc.

Useful error bounds are derived and their effectivity checked on some – one and two – dimensional test functions. Also a comparison is made with some stochastic integration methods.

ELIMINATION OF BIAS FOR GENERAL MEASURES OF ASSOCIATIONS

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(12.4.1989, supervisor V.Dupač)

Measures of association have been introduced to detect special statistical dependence of categorical variables. The thesis extends some theoretical results to a large class of measures which are representable as smooth functions of multinomial frequency vectors.

The method for arbitrarily exact approximations of expectations based on the central moments of the multinomial distribution law is formalized in the first part of the thesis. General formulas are applied to the class of logarithmic interactions and to the coefficients of explanatory decomposition power following the D–model for categorical data analysis.

The main results of the thesis are based on the explicit formula for K–th order jackknife transformation, the application of which eliminates all terms up to the order $O(N^{-K})$ in the typical bias expansion of the original estimator. General properties derived for general von Mises differentiable estimators are formalized for the class of association measures. The verification of the asymptotic normality for the basic transformation $J_K(\,.\,)$ is a generalization of a result by Parr and Tolley.

The third part of the thesis extends the above results to the situation of S independent random samples. The S–sample jackknife transformation $J_K^S(\,.\,)$ is derived from the structure of bias generated by this sample plan. The explicit computational formulas are introduced for $K = 1, \ldots, 4$.

General conclusions from the simulation experiments are illustrated by numerical examples in an appendix.

NUMERICAL MODELLING OF VISCOUS INCOMPRESSIBLE FLOW

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(17.4.1989, supervisors I.Černý, M.Feistauer)

The theme of this work is the mathematical study of one of the classical models of turbulent flow of viscous incompressible fluids. This model generalizes Prandtl's idea of mixing length.

The weak solution of the model is defined and investigated in the theoretical part. The existence of a weak solution for the velocity and the pressure is proved in spaces $\overrightarrow{W}^{1,3}(\Omega)$ and $L_{\frac{3}{2}}(\Omega)$. The nonhomogeneous boundary conditions of Dirichlet's type

for the velocity are supposed. The unicity of the weak solution for the velocity is proved for a limited set of values of physical parameters.

Nonconforming finite elements are used for the discrete approximation of the space $\vec{W}^{1,3}(\Omega)$. The sufficient condition of discrete coercivity is derived. The existence of a discrete velocity is proved under conditions which are analogous to unicity conditions of the weak solution. The unicity of discrete pressure except for an addition of a constant is proved.

The usual numerical methods are used for the practical computation of some simple cases.

SPECIAL CURVED ELEMENTS AND THEIR APPLICATION

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(19.6.1989)

Special curved elements are constructed in the submitted thesis. Further they are used to the definition of the interpolation functions and the application to the solution of contact problems by means of the finite elements method is shown.

In Chapter I the mapping F which maps a rectangle onto a triangle is defined and its main properties are proved. In Chapter II conditions laid upon the triangulation of the domain Ω are formulated and some preliminary estimates are proved. The definitions of interpolation functions of two types are contained in Chapter III. The estimates of $\|f - \varphi\|$, φ is the interpolation function associated to f, are proved in the following chapter. These estimates are used to prove convergence of the finite elements method in the case of second order homogenous boundary value problems with $\mathring{W}_2^{(1)}$ – elliptic bilinear form.

In Chapter V the finite elements method is applied to the solution of the equivalent barotropic vorticity equation. In the last chapter the same method is used to solve electro–magnetic field in the plane.

CONSULTATION SYSTEM FOR INSULINOTHERAPY OF DIABETES MELLITUS

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(29.6.1989)

The self–learning system to propose insulin therapy was developed. It is supposed to be used as a consultation system to assist the physician's decision making. The mathematical model of insulin pharmacodynamics is the main part of the system. All conventional injection therapy schemes including insulin pump treatment are supported. The parameters of the model are learned continuously during the therapy process. The methods of linear regression analysis modified with heuristic rules are used to perform the adaptation. The system proposes suitable therapy according to the individualized model. Generally, it is a combinatorical problem