Operators of the interflatation of functions of 3 variables in the 3D computer tomography

O. N. Lytvyn[1],O. O. Lytvyn[1], V. I. Mezhuyev[2], K. E. Babenko[3], Y. I. Pershina[4]

[1] Ukrainian Engineering Pedagogical Academy, Email: academ@kharkov.ua
[2] Berdyansk State Pedagogical University, Email: mejuev@ukr.net
[3] Ukrainian Engineering Pedagogical Academy, Email: kristina_babenko@mail.ru
[4] Kharkov National Technical University "Kharkov Politechnical Institute",
Email: yulia_pershina@mail.ru

ABSTRACT

Interlineation of the functions of many variables is the restoration of these functions with the help of their traces and the traces of their partial derivatives (or some other differential operators) up to a given order on a system of lines. Interflation (interflatation) of the functions of many variables is the restoration of these functions with the help of their traces and the traces of their partial derivatives (or some other differential operators) up to a given order on a system of surfaces (in particular, on flat surfaces). Interlineation and interflatation are the natural generalizations of interpolation of functions of many variables.

Here, solutions to the 3D problems of computer tomography using operators of interflatation of functions of 3 variables are proposed. In particular, a review of recent results in this direction will be given. Concrete algorithms for operators of interflatation with given projections on flat systems will be formulated.

Thus, the authors offer a new method of constructing a mathematical model of an X-ray computer tomography, which does not demand use of the spiral scheme of scanning and is based on any of the known classical schemes of reception of tomograms.

Keywords interpolation, interflatation, blending function interpolation, computer tomography.

1 INTRODUCTION

Interflatation can be used in approximation theory, in methods of the reducing the solution of the boundary value problems to the systems of the ordinary linear (LIDE) or nonlinear (NIDE) integro-differential equations, in cartography, in computer tomography, in signal processing and for describing the surfaces of cars, airplanes, cosmic bodies and so on (Lytvyn, 2000; 2004; 2005; Lytvyn and Babenko 2005; Lytvyn and Pershina 2005).

The general strategy in using interflatation operators in digital multivariate signal processing is as follows:
1. Information about an object can be given as a value recovered function in some points and as traces of this function on some lines (for example, with the help of automatic recorders) and as traces of this function on some flats or curvilinear surfaces (for example, photographs from satellites in cartography, tomograms in computer tomography etc.).
2. Digital processing of these data often must be undertaken in a short time. New methods must be faster in comparison with classical spline-interpolation methods. There are operators building with the help of interlineations and interflatation operators.
3. For more precisely recovered signals all additional information about the investigation of an object (differentiability class, some characteristic lines, surfaces into object or on an object's surface etc) must be taken into consideration. These additional data can be transformed in formulas by means of interpolation, interlineation, interflatation and blending approximation operators.
4. It is necessary to notice that interlineation, interflatation and blending approximation operators are more exact than classical polynomial, trigonometrical and spline interpolation and approximation operators, i.e. poorer quantity data can be used than in classical methods for the same exactness.
5. Algorithms in these methods use operators, which work on only one variable. This provides the possibility of using known optimal or near to optimal operators.

In the last quarter of the 20th century, computer tomographs which allow the restoration of the internal structure of a body without incision have found wide application. These include medical research, non-destructive checks on three-dimensional objects and implementation of scientific research into different areas of science and technology. The classical method of the approximation theory for processing information which acts in a tomograph is not used. There are the set of values of the researched characteristic (function of three variables) in separate points, and integrals from its (projection) along a fixed system of straight lines, or a little X-ray pictures in different foreshortenings (that is integrals from function on different directions) or traces of this function (tomograms) on the set of planes. The problem exists in the reconstruction of the internal structure of a body (probably, approximately) with help specified nonconventional information.

Assuming the following situation; the patient has passed inspection on a computer tomograph. The doctor – the operator who works behind the board of a tomograph - has decided that for a correct diagnosis to be made it is enough to receive images of internal structure of a body in some planes (not necessarily parallel). After detailed analysis of the received tomograms however, which is carried out after the patient has left a tomograph, there was a desire to view the image in other sections (in other planes). This operation can be executed with the help of operators of interflatation of the functions of three variables.

A similar situation arises when a doctor specifies a diagnosis with the help of X-ray pictures. In particular, almost everyone can understand why sometimes the doctor wants to receive not one X-ray picture, but two (received as a rule in different, but mutually perpendicular directions). It is considered that with the help of this additional picture the doctor can make a more precise diagnosis (the skilled doctor is necessary for this purpose). How can the internal structure of a body be described mathematically with the help of two, three and more X-ray pictures received in different directions? This problem can be solved with the help of operators blending approximation of functions of three variables.

Even a lay person can understand that with the exception of new mathematic methods of dealing with this information, the use of modern computer techniques (preservation of X-ray pictures or tomograms in a computer with corresponding expansion, their corresponding treatment with the help of the computer, visualization of results etc) is necessary. Interflatation operators on a system of planes parallel to the coordinate planes allow this problem to be solved if the tomograms are received on a system of mutually perpendicular planes. The general method turns out with the help of interflation operators of functions of three variable planes on a system which is not necessarily mutually perpendicular.

There are modern software packages, such as 3D Max, Adobe Illustrator and Digital Anatomy in which it is possible to receive sections of a three-dimensional body. Let's note that all of these software packages restore the internal structure of a 3D body with the help of tomograms which lay on the planes parallel to one plane. That is these software packages do not enable a section of a 3D field on the given projections received at the crossing of a body by a system of any crossed planes to be found. It is also noted that a method of restoration for a 3D body by its known tomograms which lay in system of three crossed planes, gives a more exact result than methods which are described in the packages mentioned above.

2 METHOD

Here, a more general problem – the issue of restoration to a 3D object by its traces on a system of three groups of parallel planes which are not necessarily perpendicular to coordinate axes - is considered for the first time. Besides the operator interflatation on a system of planes, each of which is not necessarily crossed with all others, is constructed in the paper for the first time.

In this work, the method of restoration of the image of the distribution of some physical characteristic $f(x),\ x=(x_1,x_2,x_3)$ of the internal structure (for example, density, coefficient of absorption, etc.) is offered. The source of the information about function $f(x)$ that is about internal structure of a 3D body, we shall consider a set of planes, and also a set of tomograms on these planes. For subsequent calculations it is necessary for some statements to be formulated.

Let three groups of parallel tomograms be set. Tomograms lie on planes which are set by equations of the following kind. The group of planes $\Pi 1$ is set by the equations: $\omega 1_i(\boldsymbol{x}) :=$ $:= \sum_{\boldsymbol{p}=1}^{3} \boldsymbol{a}_{\boldsymbol{i}\,\boldsymbol{p}} \boldsymbol{x}_{\boldsymbol{p}} - \gamma_{\boldsymbol{i}} = 0,\ \boldsymbol{i} = \overline{1,\boldsymbol{m}}$, the group $\Pi\, 2$ is set by the equations $\omega 2_{\boldsymbol{k}}(\boldsymbol{x}) := \sum_{\boldsymbol{p}=1}^{3} \boldsymbol{b}_{\boldsymbol{k}\,\boldsymbol{p}} \boldsymbol{x}_{\boldsymbol{p}} - \gamma_{\boldsymbol{k}} = 0$, $k = \overline{1,n}$ and the group $\Pi 3$ is set so $\omega 3_{\boldsymbol{l}}(\boldsymbol{x}) := \sum_{\boldsymbol{p}=1}^{3} \boldsymbol{c}_{\boldsymbol{l}\,\boldsymbol{p}} \boldsymbol{x}_{\boldsymbol{p}} - \gamma_{\boldsymbol{l}} = 0,\ \boldsymbol{l} = \overline{1,\boldsymbol{s}}$, where $\boldsymbol{m},\boldsymbol{n},\boldsymbol{s}$ - quantity of parallel planes in groups $\Pi 1, \Pi 2, \Pi 3$ accordingly. Let's enter the following designations:

$$\tau_{ik} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ a_{i1} & a_{i2} & a_{i3} \\ b_{k1} & b_{k2} & b_{k3} \end{vmatrix}; \quad \tau_{ik}^{0} = \frac{\tau_{ik}}{|\tau_{ik}|},$$

Are similarly defined τ_{il}, τ_{kl}.

$$M = \{(i,k,l) \mid A_i \cap B_k \cap C_l = V_{ikl} = (x_{ikl1}, x_{ikl2}, x_{ikl3}) \neq \emptyset \ \},$$

where A_i - the tomograms set on planes $\Pi 1_i$, $i = \overline{1,m}$, B_k - the tomograms set on planes $\Pi 2_k$, $k = \overline{1,n}$, C_l - the tomograms set on planes $\Pi 3_l$, $l = \overline{1,s}$.

$$\Gamma_{ik} = A_i \cap B_k \neq \emptyset,\ \ \Gamma_{il} = A_i \cap C_l \neq \emptyset, \quad \Gamma_{kl} = B_k \cap C_l \neq \emptyset,$$

$T_{1,i}, T_{2,k}, T_{3,l}$ – the tomogram, set on planes $\Pi 1_i, \Pi 2_k,\ \Pi 3_l$ accordingly

$$\Delta_{ikl} = \begin{vmatrix} a_{i1} & a_{i2} & a_{i3} \\ b_{k1} & b_{k2} & b_{k3} \\ c_{l1} & c_{l2} & c_{l3} \end{vmatrix}.$$

Definition: The tomogram (trace of function $f(x)$) $\varphi_k(x)$ on a plane $\omega_k(x) = 0$ provided that all three factors, that is $\boldsymbol{a}_{\boldsymbol{i},\boldsymbol{p}}, \boldsymbol{i} = \overline{1,\boldsymbol{m}}$ and $\boldsymbol{b}_{\boldsymbol{k},\boldsymbol{p}}, \boldsymbol{k} = \overline{1,\boldsymbol{n}}$ and $\boldsymbol{c}_{\boldsymbol{l},\boldsymbol{p}}, \boldsymbol{l} = \overline{1,\boldsymbol{s}}$, are not equal to zero, we shall name one of three functions

$$T_k(x) = \begin{cases} f(x_{1k}(x_2,x_3), x_2, x_3) \\ f(x_1, x_{2k}(x_1,x_3), x_3) \\ f(x_1, x_2, x_{3k}(x_1,x_2)) \end{cases} = \begin{cases} f((\gamma_k - a_{k2}x_2 - a_{k3}x_3)/a_{k1}, x_2, x_3) \\ f(x_{1,}(\gamma_k - a_{k1}x_1 - a_{k3}x_3)/a_{k2}, x_3) \\ f(x_1, x_1, (\gamma_k - a_{k1}x_1 - a_{k2}x_2)/a_{k3}) \end{cases} \tag{1}$$

$$T_k(x) = f(x)\big|_{\omega_k(x)=0},\ \omega_k(x) = \omega 1_k(x)\ \ or\ \omega_k(x) = \omega 2_k(x)\ or\ \ \omega_k(x) = \omega 3_k(x)$$

Theorem 1: For the existence of function $L_{ikl}(x) \in C^r(R^3)$ with the set tomograms $\boldsymbol{T}_{1,\boldsymbol{i}}, \boldsymbol{i} = \overline{1,\boldsymbol{m}},\ \boldsymbol{T}_{2,\boldsymbol{k}},\ \boldsymbol{k} = \overline{1.\boldsymbol{n}},\ \boldsymbol{T}_{3,\boldsymbol{l}},\ \boldsymbol{l} = \overline{1,\boldsymbol{s}}$, for which a condition satisfied

$$L_{ikl}(x)\big|_{\Pi 1_i} = T_{1,i}(x)\big|_{\Pi 1_i},\ L_{ikl}(x)\big|_{\Pi 2_k} = T_{2,k}(x)\big|_{\Pi 2_k}, \quad L_{ikl}(x)\big|_{\Pi 3_l} = T_{3,l}(x)\big|_{\Pi 3_l}$$

is necessary and enough that traces $T_{q,d}(x), q = 1,2,3,\ d = i,k,l$ satisfied to a condition $T_{q,d}(x) \in C^r(R^3),\ r \geq 0$ and S.M. Nicolsky's conditions, which on an edge Γ_{kl} are reduced before check of equality

$$T_{2,k}(x)\big|_{\omega 3_l(x)=0} = T_{3,l}(x)\big|_{\omega 2_k(x)=0}.$$

These conditions on edges Γ_{ik}, Γ_{li} have a similar kind. In a point V_{ikl} of Nicolsky's conditions are reduced to check of equality

$$T_{3,l}(x)\Big|_{\omega 1_i(x)=0,\omega 2_k(x)=0} = T_{2,k}(x)\Big|_{\omega 3_l(x)=0,\omega 1_i(x)=0} = T_{1,i}(x)\Big|_{\omega 2_k(x)=0,\omega 3_l(x)=0}.$$

The operator $L_{ikl}(x)$ it is possible to construct as

$$L_{ikl}(x) = L_{ikl}(\{T_{q,d}\},x) = \left[L_{ik}^l + L_{kl}^i + L_{li}^k - L_{li}^k L_{kl}^i - L_{kl}^i L_{li}^l - L_{li}^k L_{ik}^l + L_{ik}^l L_{kl}^i L_{li}^k\right](\{T_{q,d}(x)\},x),$$

where

$$L_{ik}^l(\{T_{q,d}(x)\},x) = T_{3,l}(x) = f(x)\big|_{\Pi 2_l} \qquad L_{ik}^l L_{kl}^i(\{T_{q,d}\},x) = f(x)\big|_{\Pi 1_i,\Pi 2_l} \tag{2}$$

$$L_{ik}^l L_{kl}^i L_{li}^k(\{T_{q,d}\},x) = f(V_{ikl}),\ q=1,2,3,\ d=i,k,l.$$

Operators $L_{kl}^i, L_{li}^k, L_{kl}^i L_{li}^k, L_{li}^k L_{ik}^l$ are similarly defined.

Theorem 2: Assuming that the internal structure of a 3D body is described by function $f(x) \in C^r(R^3)$ $(r \ge 3)$ which has the set tomograms and satisfies to conditions

$$f(x)\big|_{\Pi 1_i} = T_{1,i}(x)\big|_{\Pi 1_i},\ f(x)\big|_{\Pi 2_k} = T_{2,k}(x)\big|_{\Pi 2_k}, \tag{3}$$

Then for an error $R_{ikl}f(x) = (I - L_{ikl})f(x)$ of the approximation restoration of internal structure $f(x)$ the operator $L_{ikl}f(x)$ constructed with the help of the given set of tomograms, satisfies equality

$$R_{ikl}f(x) = \int_0^{\omega 1_i}\int_0^{\omega 2_k}\int_0^{\omega 3_l} \frac{\partial^3}{\partial t_i\,\partial t_k\,\partial t_l} f\left(V_{ikl} + \frac{\tau_{kl}}{\Delta_{kli}}t_i + \frac{\tau_{li}}{\Delta_{lik}}t_k + \frac{\tau_{ik}}{\Delta_{ikl}}t_l\right) dt_i\, dt_k\, dt_l \tag{4}$$

Theorem 3: Let the set of three groups of parallel tomograms which are placed on planes which are set by the equations

$$\Pi 1_i : \omega 1_i(x) = 0,\ i = \overline{1,n},\ \ \Pi 2_k : \omega 2_k(x) = 0,\ k = \overline{1,m},\ \ \Pi 3_l : \omega 3_l(x) = 0,\ l = \overline{1,s},$$

satisfies two conditions:

1. In one point $V_{ikl} = A_i \cap B_k \cap C_l$ it has crossed no more than three tomograms;
2. Each tomogram of one group is crossed with each tomogram of other two groups (and inside group of the tomogram are parallel, that is are not crossed).

Then the system of functions

$$h_{ikl}(x) = \frac{\prod\limits_{\substack{j=1\\ j\ne i}}^{m}\omega 1_j(x)\ \prod\limits_{\substack{j=1\\ j\ne k}}^{n}\omega 2_j(x)\ \prod\limits_{\substack{j=1\\ j\ne l}}^{s}\omega 3_j(x)}{\prod\limits_{\substack{j=1\\ j\ne i}}^{m}\omega 1_j(V_{ikl})\ \prod\limits_{\substack{j=1\\ j\ne k}}^{n}\omega 2_j(V_{ikl})\ \prod\limits_{\substack{j=1\\ j\ne l}}^{s}\omega 3_j(V_{ikl})}, \qquad i = \overline{1.m},\ k = \overline{1,n},\ l = \overline{1,s}$$

has properties

$$h_{ikl}(V_{ikl}) = \delta_{i,i'}\delta_{k,k'}\delta_{l,l'},\ i,i' = \overline{1,m},\ k,k' = \overline{1,n},\ \ l,l' = \overline{1.s}.$$

Theorem 4: Let tomograms $T_{q,d}(x) \in C^r(R^3),\ \ r \geq 3,\ q = 1,2,3,\ d = i,k,l$ satisfy Nikolsky's conditions on edges and in points of crossing of planes. Then function

$$L(x) = \sum_{i=1}^{m} \sum_{k=1}^{n} \sum_{l=1}^{s} h_{ikl}(x) L_{ikl}(x) \tag{5}$$

is polynomial interflatant with properties

$$L(x) \in C^r(R^3), \quad L(x)\big|_{\Pi1_i} = T_{1,i}\big|_{\Pi1_i}, L(x)\big|_{\Pi2_k} = T_{2,k}\big|_{\Pi2_k}, L(x)\big|_{\Pi3_l} = T_{3,l}\big|_{\Pi3_l}, i = \overline{1,m},\ k = \overline{1,n},\ \ l = \overline{1,s}\cdot$$

Thus $\forall f(x) \in C^r(R^3),\ r \geq 3$ which satisfies to conditions (3), equality is carried out

$$\begin{aligned} &L(x) = Lf(x):\ f(x) = Lf(x) + R\,f(x) \\ &Rf(x) = \sum_{i=1}^{m} \sum_{k=1}^{n} \sum_{l=1}^{s} h_{ikl}(x) R_{ikl} f(x) \end{aligned} \tag{6}$$

where $R_{ikl} f(x)$ is defined by equation (4).

Let's consider this general theory using the example of a special case where the three-dimensional object by the given tomograms on system of mutually perpendicular planes is restored. We shall consider a body (without restriction of a generality) completely placed in a unit cube $D = [0,1]^3$.
As the source of the information on function $f(x, y, z)$ about the internal structure of a body is a set of picture $X_k.bmp, k = \overline{1, M_1},\quad Y_l.bmp, l = \overline{1, M_2},\quad Z_p.bmp, p = \overline{1, M_3}$ which are perpendicular according to axes OX, OY, OZ. To each picture we put in conformity function:

$$\begin{aligned} X_k.bmp &\mapsto A(k, y, z),\ k = \overline{1, M_1},\ \ 0 \leq y \leq 1,\ 0 \leq z \leq 1; \\ Y_l.bmp &\mapsto B(x, l, z),\ l = \overline{1, M_2},\quad\ 0 \leq x \leq 1,\ 0 \leq z \leq 1; \\ Z_p.bmp &\mapsto S(x, y, p),\ p = \overline{1, M_3},\ \ 0 \leq x \leq 1,\ 0 \leq y \leq 1, \end{aligned}$$

Theorem 5: Let operators $In1\,f,\ In2\,f,\ In3\,f$ be operators of spline-interpolation of function $f(x, y, z)$ with respect to variables $\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}$ accordingly:

$$\begin{aligned} &In1\,f(x, y, z) = \sum_{k=1}^{M_1} Sp_{M_1,\kappa}(x) A(k, y, z),\ \ In2\ f(x, y, z) = \sum_{l=1}^{M_2} Sp_{M_2,l}(y) B(x, l, z), \\ &In3\,fx, y, z) = \sum_{p=1}^{M_3} Sp_{M_3,p}(z) S(x, y, p), \end{aligned} \tag{7}$$

where $Sp_{M_1,k}(x)$ – basic splines of the a degree $m\ (m = 1, 2, 3)$ with such properties:

$$\boldsymbol{Sp}_{\boldsymbol{M}_1,\boldsymbol{k}}\left(\frac{\boldsymbol{p}}{\boldsymbol{M}_1}\right) = \delta_{\boldsymbol{k},\boldsymbol{p}},\ \boldsymbol{k}, \boldsymbol{p} = \overline{0, \boldsymbol{M}_1}\ .$$

Such splines $Sp_{M_2,l}$, $Sp_{M_3,p}$ are similarly defined.
If functions $A(k, y, z),\ k = \overline{1, M_1},\quad B(x, l, z),\ l = \overline{1, M_2},\quad S(x, y, p),\ p = \overline{1, M_3}$ satisfy such conditions

$$A(k, y_l, z) = A(x_k, l, z);$$
$$B(x, l, z_p) = B(x, y_l, p);$$
$$S(k, y, z_p) = S(x_k, y, p),$$

that the operator the spline-interflatation

$$Lu(x, y, z) = (In1 + In2 + In3 - In1In2 - In1In3 - In2In3 + In1In2In3) f(x, y, z)$$

has the following properties

$$Lf(k, y, z) = A(k, y, z), k = \overline{1, M_1};$$
$$Lf(x, l, z) = B(x, l, z), l = \overline{1, M_2};$$
$$Lf(x, y, p) = S(x, y, p), p = \overline{1, M_3}.$$

3 RESULTS

The entrance data of the program is set of the equations of planes which represent crossings 3D body which describes function $f(x, y, z)$ in a system of three groups of parallel planes, which are not perpendicular to axes of coordinates (in the first group m of parallel planes, in the second - n planes, in the third - s planes). Each of the three planes taken from different groups is crossed in one point. On this set of planes the file of planes ω (the first m places of a file occupy planes from the first group, behind them planes from the second group settle down, and farther planes from the third group) is under construction. The file of planes ω has all $m + n + p$ of planes.

Operators a spline - interflatation are realized in the program by separate functions $L1(i, k, l, x)$, $L2(k, l, i, x)$, $L3(l, i, k, x)$, $LL1(k, l, i, x)$, $LL2(l, i, k, x)$, $LL3(i, k, l, x)$, $LLL(i, k, l, x)$. These functions correspond to the operators determined by formula (3). Each of these functions carries out a calculation of numbers, most close to a point with coordinates x_1, x_2, x_3, pictures and under these numbers addresses to concrete elements of a file of pictures.

Feature of computer realization of operators $L1(i, k, l, x), L2(k, l, i, x), L3(l, i, k, x), LL1(k, l, i, x)$, $LL2(l, i, k, x), LL3(i, k, l, x)$, $LLL(i, k, l, x)$ consists in the necessity of an action on each of *RGB* a component of color separately. Thus, in functions $L1(i, k, l, x), L2(k, l, i, x), L3(l, i, k, x), LL1(k, l, i, x)$, $LL2(l, i, k, x)$, $LL3(i, k, l, x), LLL(i, k, l, x)$ allocation separate a component of color in the given point is carried out.

Let's show results of work of the program which allows founding sections of a 3D body in any plane with help the tomograms in three mutually perpendicular planes *(Brain.m)*. For comparison we given also sections of a 3D body in this plane with help the tomogramms in planes, perpendicular only to an axis *OX (Brainox.m)* or only axis *OY (Brainoy.m)* or only to axis *OZ (Brainoz.m)*.

Taking as an example the data of Radon sent to the software package “Digital Anatomist” (100 pictures, perpendicular axes *OX*, 110 pictures, perpendicular axes *OY*, 35 pictures, perpendicular axes *OZ*). All pictures are taken with a constant step of 1,3 mm.

Figure 1: An example of tomograms, perpendicular to axes OZ

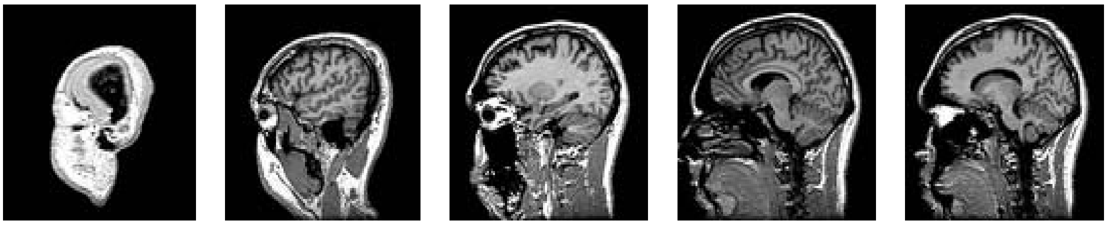


Figure 2: An example of tomograms, perpendicular to axes OY.

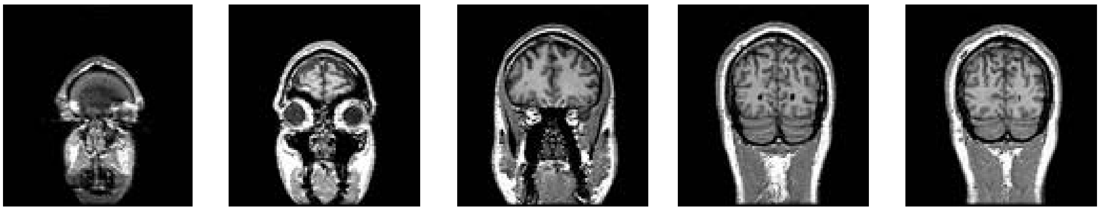
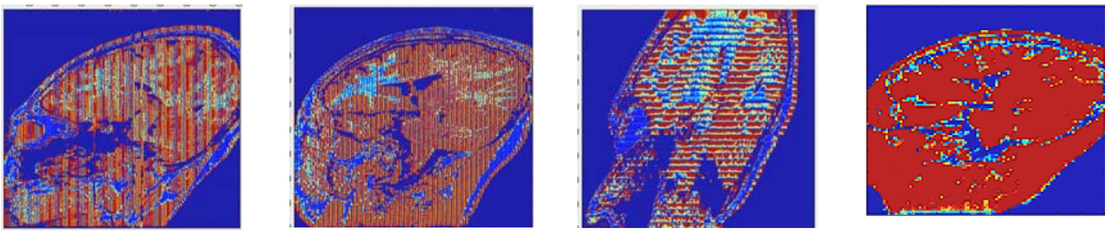


Figure 3: An example of tomograms, perpendicular to axes OX.

In all four programs the section of a brain was searched by a plane set by the equation: *x+y+10z+1=0.* The following results have been received.



a **b** **c** **d**

Figure 4: a) Result of the program Brainox;
b) Result of the program Brainoy;
c) Result of the program Brainoz;
d) Result of the program Brain

From the images in this section we can say that with help the data (tomogramms) in all mutually perpendicular planes the images are visible, providing more detail than on the data (tomogramms), which is parallel to any one plane.

The results stated above can be generalized on a case when instead of interflatation operators for the reconstruction of an internal structure 3D bodies are used as operators of the blending approximation in whom the entrance information are the X-ray pictures received in various directions. In particular, in the patents (Sergienko, 2007) the described method has a non-destructive application for industrial tomography i.e. in customs checks. In these patents, mathematical models of the reconstruction of internal structure 3D bodies with the help of two or three X-ray pictures in mutually perpendicular directions are described. This method can used by customs officials to check lorries with big size.

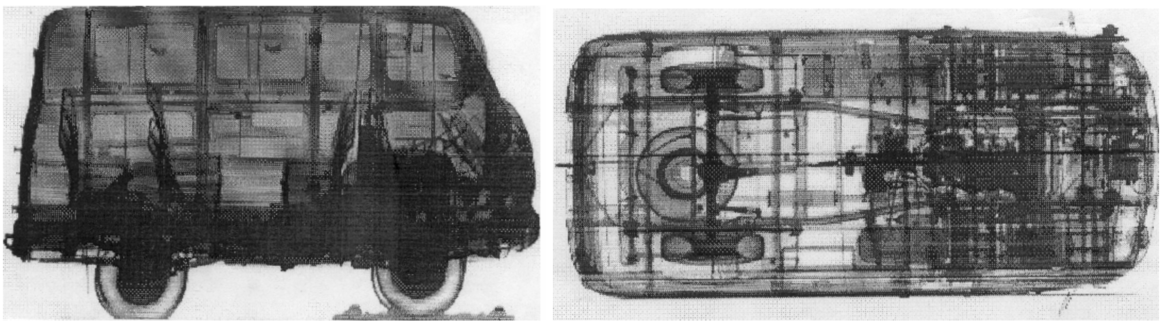


Figure 5. Two X-ray projections of cars for custom checking

4 CONCLUSION

Thus, in the given work the technique of restoring the internal structure of a three-dimensional body on any system of tomograms located on three groups of crossed planes, each of which will consist of the planes parallel among themselves is offered. This method was devised for the creation of software for working computer tomographs.

Thus, the authors of this work present the method of construction 3D model the inner structure body that is completely new and distinct from using in existing computer tomographs. We invite for cooperation for building the software both for existing computer tomographs and for new ones.

5 REFERENCES

LYTVYN O.N., (2000), Methods of a solution of a boundary value problems of continuum mechanics, reducing to the systems of ordinary linear (LIDE) or of ordinary nonlinear (NIDE) integro-differential equations, *Numerical Modeling in Continuum Mechanics. Proceed. of the 4th Summer Conference Held in Prague,* 240-249.

LYTVYN O.N. (2004), Interlineation and interflation functions of many variables (blending function interpolation) and economical algorithms in the approximation theory, The International Conference of Computational Mathematics, *Computational Methods Singapore.(G.R.Liu, V.B.C.Tan, X. Han,editors). Band 2, Springer, 1105-1110.*

LYTVYN O.N., (2005), Inerlineation and interflation function many variables (the blending function interpolation) and multidimensional signal processing, *Proc. International scientific conference «Signal and Image Processing», Novosibirsk,* 280-285

LYTVYN O.N., and BABENKO K.E. (2005), The mathematical modeling in the computer tomography with using direct Fourier method and spline-interlineation of the functions, *Proc. International scientific conference «Signal and Image Processing», Novosibirsk,* 268-273

LYTVYN O.N., and PERSHINA Y.I., (2005), Reconstruction of 3D objects with use interflation of functions, *Proc. International scientific conference «Signal and Image Processing», Novosibirsk, 274-279*

SERGIENKO I.V., LYTVYN O.M., MEZUEV B.I., UDOVICHENKO V.M., and LYTVYN O.O. (2007), Way of restoration of internal structure of three-dimensional object (by two X-ray pictures). Patent № 78568

SERGIENKO I.V., LYTVYN O.M., and LYTVYN O.O. (2007), Way of restoration of internal structure of three-dimensional object (by three X-ray pictures). Patent № 78569

NATTERER F., (1986), *The mathematics of computerized tomography,* New York: Wiley-Teubner