TOPOLOGICAL MODELLING OF CARCASSES IN THE SYSTEMS OF AUTOMATION AND ROBOTIZATION OF PRIMARY PROCESSING OF CATTLE

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SUMMARY

Some slaughter operations - bleeding, separation of extremities and heads, evisceration, splitting of carcasses into halves, quarters and cuts are psycologically difficult for human beings. For this reason one of the directions of automation and of robotization of these processes is connected with creation of a topological model of the animal carcass, which can ensure control of mechanical tools, manipulators and intellectual robots through computer.

INTRODUCTION

Technological model of a carcass, defining geometrical coordinates of points on the surface of a carcass and positions of inner organs, is created on the basis of statistic information on dimensions and interrelated positions of carcass sites and also on key points, necessary for performing of certain technological operations for primary processing of cattle.

MATERIALS AND METHODS

Statistic data analysis for pigs showed that dispersions and mean square deviations of key points coordinates on a carcass within the allowed shift of a working tool are observed only for the same breed, weight and age of the animal. With the account of these factors in the database the following information on a carcass is systemized:

weight; age; length; circumference of breast (A); height in withers; depth of breast; width of breast; length of side; distance from circumference line (fig.1) to plate; Distance from circumference line to snout; distance from plate to stab point; distance between stretched legs; distance from plate to stretched extremity; diameter of metacarpus under fetlock joint; distance from root of tail to snout; distance from shackling point to snout.

We processed data on measurements of 175 pigs of the same breed. To establish homogeneity of data with the check-out of zero-hypothesis on Cohrain criterion, random excerpts comprising 30-35 values were studied. Calculations of statistic characteristics and of correlation coefficients in general didn't reveal any dependencies between parameters of an animal. However, within group of animals of the same breed, weight and age, the ratio of dimensions by each of the three axles of measurements turned to be practically constant and were characterized by the highest values of correlation coefficients.

With the account of each group of animals standard topological model is created, representing bulk of data on the complex of mean dimensions and key points of surface and cuts of a carcass in the given orientation system.

Visually (on display or on the list output) this topological model is presented as topo-

grapho-anatomic charts of projections of lengthwise and crosswise cuts of a carcass for different breeds and ages of animals. Upon dividing of charts by coordinate grid with pitch h, it is possible to determine spatial coordinates of different points and sites of body of a model animal with accuracy to a pitch. The set of such charts allows to determine location of each anatomic point using three coordinates, and subsequently of each organ in interconnection with external topology of animal body.

Empiric determination of coordinates of anatomic points and the study of topographic and anatomic regularities are performed according to the method of coordinate and figure measuremetry, based on messuring of an object in measures (quanta) or in parts of the main dimension, equalled to the pitch of topologic grid h, this allowing to discover accurately topographic and anatomic characteristics of animals of different breeds and ages.

For the study of topography of organs and of anatomic sites, showing relatively plain surface, linear and rectangularly-coordinated measurements are used. For anatomic sites with round or spheric surfaces, coordinate-figured topographo-anatomic charts with measuremetric grid are compiled, which, along with organs topography reflect shape of anatomic site. A useful method of obtaining of projectional topographo-anatomic data for measuremetric analysis is mirror sightography, allowing to execute projectional drawing of an object from two and more mutually perpendicular sites.

Measurements in "measures" and metric units (cm, mm) are taken with slide calipers, they are also used for measuring of graphic images (videograms, dioptograms, rhentgenograms) and of live objects also. Measurements on the round parts of animal body are taken with the help of so-called measuremetric gusset plate.

For such technological operations as stunning and bleeding of pigs measurements were taken on a stunned and vertically fixed animal (fig. 1); the following distances were included in database:

- from the level of breast circumference to plate;
- from snout to plate;
- from shackling point to snout;
- from stab point to snout.

In technological processes of primary processing of cattle working organs of manipulator robots should be driven to a predetermined point (of stunning, bleeding etc.) or to group of points along processing line (splitting, legging etc.). However, each separate carcass, loaded on conveyor, possesses its own dimensions and topology (exterior and interior), differing from the average standard topological model of the animal. Thus, for precision of coordinates X_i, Y_i, Z_k of key anatomic and technological points, correction of standard model is needed, bearing in mind constant ratio of dimensions along each measuring coordinate according to the following formulae:

$$X_i = a_i X_o K_x;\ i=\overline{1,n}\ ;\ K_x = \frac{X}{X_o}\ ;$$

$$Y_i = b_j Y_o \cdot K_y;\ j=\overline{1,m};\ K_y = Y/Y_o;$$

$$Z_1=C_1Z_oK_z;\quad 1=\overline{1,p}\ ;\ K_z=Z/Z_o;$$

where $a_ib_jc_1$ - ratio coefficients, characterizing position of the required point (i,j,1) in the standard topological model in relation to dimensions X_o,Y_o,Z_o;

K_x,K_y,K_z - correlation coefficients of the model;

X,Y,Z - dimensions of concrete animal by three axles of measuring, correspondingly.

Thus, when the animal is loaded on conveyor, its length, height and width are measured and the model, determining position of separate carcass parts, is agjusted for robotized execution of technological operations on the concrete carcass. For this, according to actual dimensions,pitch of the grid h is changed with the help of recalculation coefficient:

$$h_x=h_oK_x;\ h_y=h_oK_y;\ h_z=h_oK_z$$

Coordinates of inner organs of the animal will be determined with satisfactory degree of accuracy by discrete point i,j,1 of topological grid with pitch h_x, h_y, h_z.

Common algorithm of technological operation on primary processing of cattle in a robotized system can be expressed as follows:

1. Introduction of initial data - weight, age, breed.
2. Compilation of the model of the animal with pitch h_o.
3. Correction of grid pitch according to control measurements.
4. Precision of locations of orientation points of topological grid and of inner organs being object of technological operation.
5. Presentation of morphological grid of the needed site of animal body or of inner organ. Pitch of the grid should be chosen with due regard for convenience and reliability of determination of the point to be operated.
6. Determination of control point of location of the precised grid of the site.
7. Determination of coordinates of the point to be operated.
8. Placement of a working tool in the point to be operated.
9. Moving of the conveyor. Fixation of carcass position for further operation step.
10. Change of topological grid with the account of new dimensions of a carcass after previous operation.

Software for topological modelling of carcasses includes modules of accumulation of information on dimensions of animals and on location of support points for each technological operation.

In a dialogue regime breed, age, weight and the required technological operation for the batch of animals are fixed by indication of corresponding positions in proposed menues.

Names of databases are formed from the common name, defining notional content of the stored information and combinations of symbols of the name, compiled according to choice of points.

SRGAB - Database of mean statistic parameters of each animal breed, separately for each weight group.

KT1 - Coordinates database of key points by topographic grid for each technological operation.

RKIJ - Base of calculated and real coordinates of key points for each operation.

After determination of the main characteristics of the animal batch the choice of calculation operations with database and modelling regimes is proposed.

Filling of database

In the chosen database RKIJ dimensions of each of the conveyed animal are introduced: X - distance from snout to root of the tail; Y - height in withers; Z - width of breast. Reading of these parameters can be done by photosensors.

From database SRGAB dimensions of average statistic animal of this breed and age are read-out (XO,YO,ZO).

From database KT1 coordinates of key points for the chosen technological operation are taken (XOP,YOP,ZOP).

Coordinates of support points with the account of coordinate coefficients are calculated as follows: X_i=XOP • X/XN ; Y=YOP•Y/YN; Z=ZOP•Z/ZN

In the program,introduction of coordinates of actual location of key point for each animal is forseen for accumulation of statistic data. Processing of accumulated information will allow to obtain value of key points for each technological operation and will also make possible to evaluate deviation between calculated and real parameters for definite batches of cattle.

Correction of database

In the regime of going through database and introduction of the required correction for the chosen technological operation,display output of real and calculated coordinates for this operation is organized.

Statistic analysis includes determination of mean statistic values of real coordinates of key points with their further printing out of each technological operation.

The program was worked out on IBM PC in the FOXBASE system.

REFERENCES

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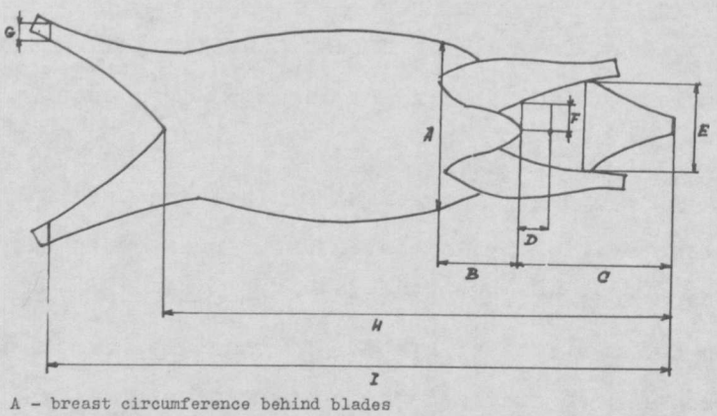
Fig. 1 Dimensions of a carcass



A - breast circumference behind blades
B - distance from circumference line behind blades to plate;
C - distance from circumference line to snout
D - distance from plate to stab point (where knife is inserted);
E- distance between stretched legs;
F - distance between plate and stretched extremity
G - diameter of metacarpus under fetlock joint
H - distance from root of the tail to snout; I - distance from shackling point to snout.