A Method for Leather Quality Determination using Fuzzy Neural Networks

Kaloyan Krastev, Lidiya Georgieva

Abstract: *In the present work an application of fuzzy neural networks for leather quality determination is investigated. An overview of the surface defects characteristics and their significance has been made. For leather quality estimation the most important features are the size and the location of the defects. These characteristics are measured using image analysis and they are used by fuzzy neural network for determination of the leather quality.*

Key words: *Leather, Quality Determination, Quality Groups, Surface Defects, Leather Classification, Fuzzy Neural Networks.*

INTRODUCTION

The surface defects are main factor in the leather quality estimation process. Because of the subjective human-expert assessments and the lack of general criteria there is no universal standard for measure the characteristics of the defects. Most often these characteristics determine three or four quality grades, which are formed on the base of features like the size and the location of the defects on the surface, the correlation between the usable and the unusable areas, the type of the leather, etc.

In [6] four quality groups, depending on the proportion of the usable and the total leather area are described. Also the leather product categories are shown, for which the respective quality grade is most appropriate. This manner gives a limited assessment of the sample usability because there is no reading of the location of the defects.

Other authors defined three quality groups for cattle hides [5]. They use the size and the location of the defects as measure of the samples' grade. That classification defines clear quality criteria and is suitable for using by the producers of this kind of hides.

In the presented project [1] an attempt for definition of quality standard to categorize skins and a global concept for the leather quality estimation has been made. A block-scheme with modules for supply chain analysis, automatic defects detection and virtual digital nesting is shown. Also there are modules for storing the obtained results in database and digital maps and for exchanging the information through the communication channels. However in this project the presence of surface defects is the only quality measure for classification of the leathers, without consideration of their chemical, physical and mechanical characteristics.

For replacement of the subjective human-expert assessment in the classification of leather depending on their surface defects, methods for image processing can be applied. In that way this process could be automated. In [2] a method is presented where the leather images are segmented first and then the contours of the defective areas are extracted. The sample quality group is determined by an algorithm for estimation of its usable area.

The presented solutions for classification of leather in quality groups use limited number of defects' characteristics and do not give decision for the most rational use of the samples. In this work a method for leather classification by using bigger set of characteristics and fuzzy neural networks is proposed.

LEATHER QUALITY DETERMINATION

To describe the classification rules it is necessary to analyze the leather model and its areas to be differentiated. On fig.1 the subdivisions of the hide are shown.

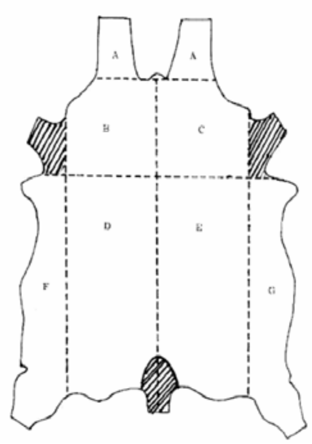

Fig.1. Subdivisions of a hide.

The particular parts are: A is the head area; B and C - the shoulders; D and E - the bend; F and G - the belly.

Best physical and mechanical characteristics (thickness, strength, durability, minimum stretch) have the D and E areas. They are most suitable for goods which need bigger leather pieces. Areas A, B and C also possess good physical and mechanical qualities, but usually they have more surface defects (scars, scratches, wrinkles). The worse thickness and strength of the F and G areas limit their application. By these reasons the presence of defects is most unwanted in the areas D and E which decrease the samples' quality most significantly. The damages in the leather ends are less important. Another key feature which has to be counted is the area of the defective regions – the bigger ones worsen vastly the sample's quality.

The exact features values determination is hardly achievable because of the subjective way for defects detection. This imposes the using of modern technical solutions for resolving on that problem and realization of a system for leather quality assessment. In that way the process will be faster and more reliable, the influence of the subjective factors and the misclassification errors will decrease.

The designed system for leather quality determination must contain few general modules which are shown on fig. 2. It will give the possibility for automatic classification of leather in quality groups.

The problems for leather image analysis and surface defects detection are examined in [3]. A programming product for registering and storing the laboratory data and leather areas determination is implemented in [4]. For receiving the final quality evaluation it is needed to take into account the location of the defects on the sample's surface. On this basic information a report about the quality is possible to be made.

The main steps of the method for leather quality determination realized by the proposed system (fig. 2) are as follow:

1. Image capturing – determine the conditions for obtaining the leather images;
2. Segmentation and Binary image receiving – include methods for image processing and surface defects detection;
3. Marking of the defects – labeling the detected defects;
4. Areas determination – assessment of the total, usable, unusable, etc. areas;
5. Defects location analysis – estimation of the significance of the defects depending on their situation over the leather;
6. Quality classification using fuzzy neural networks – evaluation the grade of a sample by preliminary trained fuzzy neural network as member to a quality group;

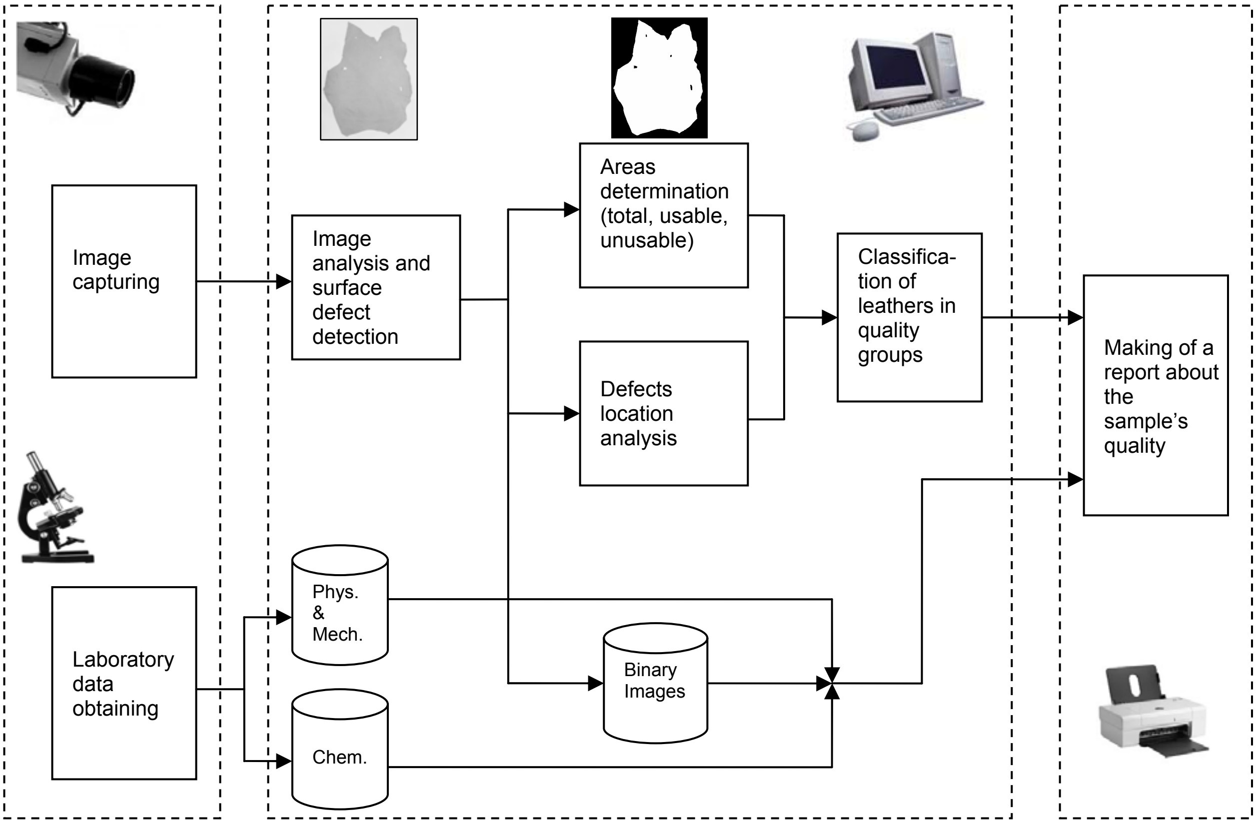

Fig. 2. The leather quality classification system design.

To calculate the grade of the leather, the features which are used have not exactly defined values, but they are "fuzzy" by their nature. Because of that in the classification process it is reasonable to apply the fuzzy logic theory.

The leather quality depends on the area of the blemishes, their number and location on the surface. These features are measured from the binary image of the sample which is obtained previously (fig.2). It consists of the leather contours and the contours of the detected defects on its surface. For simplification of the processing the image has to be oriented along the Y axis regarding the backbone line. From there the total area of the sample and the blemishes are measured by multiplying their number of pixels to the image resolution.

To evaluate the location of the defects it is needed to establish a coordinate system and its axes. Because the most important part of the leather is its central area then the assessment of the defects location must be done regarding their nearness to the inner regions or the edges. For these reasons it is suitable as coordinate axes to be used the middle horizontal and vertical lines (x_0 and y_0) of the inscribed rectangle with maximum area into the sample's contour (fig. 3). The location of the defect is estimated by the distance between its center of mass (x_i, y_i) and the axes. These two distances are normalized by the maximum length between the central lines and the most distant points of the contour in horizontal and vertical direction. The detailed description of the way for determination of the axes location, the center of mass and the area of the defects is out of scope of the current article.

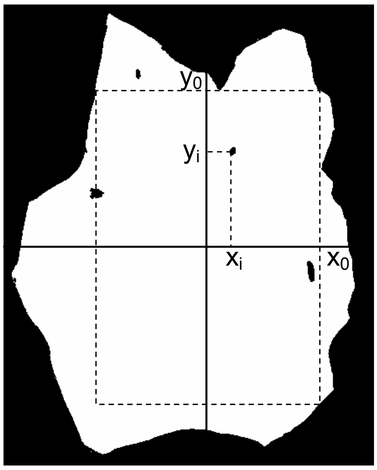

Fig. 3. Assessment of the defects location.

The above defined features determine the input linguistic variables (LV's) used for evaluation the significance of the defects – LV Area, LV Horizontal Distance (HDist) and LV Vertical Distance (VDist). They are implemented into a fuzzy neural network which structure is shown on fig. 4:

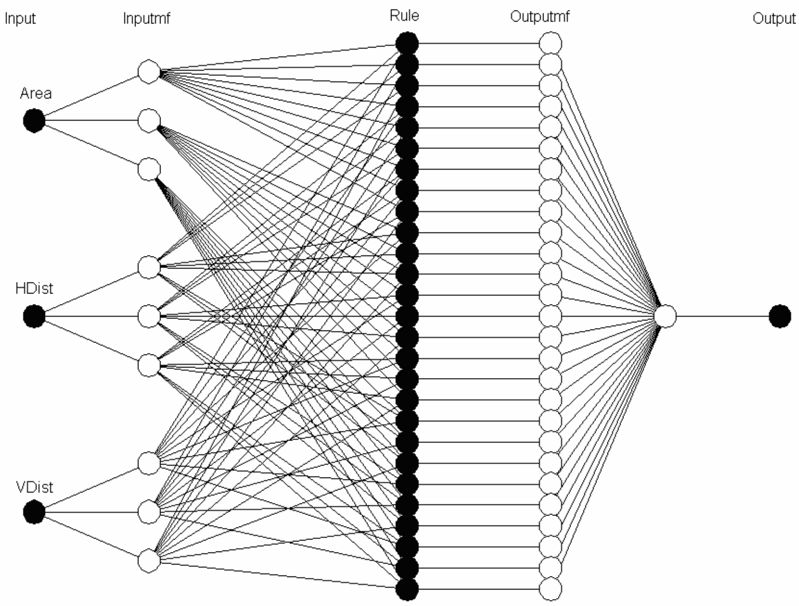

Fig. 4. Fuzzy neural network for evaluation the defects' significance.

All input LV's have three Linguistics terms. For LV Area they are marked with the linguistic terms (LT's) Small, Medium and Big corresponding to the size of the defect and the LT's for LV HDist and LV VDist are Near, Middle and Far corresponding to the distance between the axes and defect's center of mass. Most important are the defects which have big area and are located in the inner parts of the sample and less important are those with small size and near the edges situation. The output linguistic variable is the LV Significance which gives a measure about the degree of influence of the defect at the leather quality. The network has 27 hidden layer nodes equal to the full combination of fuzzy rules.

The presented fuzzy neural network (FNN1) is realized using Fuzzy Logic Toolbox of MATLAB 7.0. It is trained with a large set of input vectors and the influence of the membership functions (MF's) type is investigated. Minimal error rate is achieved using Sigmoidal and Gaussian forms of the MF's.

The result of the application of the above described fuzzy neural network is an assessment of the significance of the particular defect. But for the leather classification to given quality group it must be taken into account the whole number of blemishes and their significance as well as the unusable area quantity.

For this classification another fuzzy neural network (FNN2) is used with similar structure as the one shown on fig. 4. Here four LV's are applied – LV LSign, LV MSign and LV BSign corresponding accordingly to the number of the defects with low, medium and big significance and LV Unusable Area (UArea). The quantity of the unusable area is determined by the algorithm given in [4]. The number of LT's for the LV UArea can vary depending on the requirements of given standard or classification rule. In the current design three LT's are used. The number of the defects by their significance is received from the output of the FNN1 and they have three LT's – Small, Medium and Big.

The consequent of the fuzzy inference (the output LV) is the quality group to which the analyzed sample must be classified. In the current design the output LT's are Class1, Class 2 and Class 3. The network is trained with a set of input vectors and the form of the MF's is again investigated.

The proposed method for leather quality determination is tested with real leather images and the results about defects significance for the sample given at fig.3 is shown in table 1.

Table 1. Experimental results about defects significance.

№	Area	HDist	VDist	FNN1 output
1	0.91	0.6	0.18	1.04
2	0.85	0.56	0.13	1
3	0.78	0.16	0.37	0.974
4	0.42	0.42	0.75	0.54

There are four surface defects, three of them with output value corresponding to big significance (FNN1 output ≈ 1) and one with medium (FNN1 output ≈ 0.5). FNN2 classifies this particular sample as Class2 leather.

CONCLUSIONS AND FUTURE WORK

In the present work a method for leather quality determination using fuzzy neural networks is proposed. A system for quality estimation of leather is designed and the major steps of the method are described. Two fuzzy neural networks are proposed – one for assessment of the significance of the leather surface defects and another for classification of the samples to a quality group.

As a result from the work the following conclusions could be summarized:

1. The proposed method uses fuzzy neural networks for evaluation of the leather quality. This gives some advantages about optimal solution determination. The training of the proposed fuzzy neural networks is especially useful for the purposes of the leather quality estimation because of the possibility for using big number of data concerning different defects on leather. Such methods are not applied for quality determination of leather.
2. Different standards and classification rules use mainly the size of the usable area as the basic indicator of the quality. The proposed method expands the leather quality parameters set. It counts the location and the numbers of the defects as additional quality parameters.
3. The method gives the possibility of objective assessment of the leather quality. It is a part of a system for leather quality determination.

As directions for future work the following problems could be noticed: expanding of the training sets for bigger variety of leather types; implementing of the proposed method in a completed system for leather quality determination.

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