Edge Detection of Welding Seam Image Based on Two-dimensional Fuzzy Entropy and Genetic Algorithm

Dang xiangying[1,2,a], Li dan[1,2]

[1]Xuzhou Institute of Technology, Xuzhou, China

[2]Xuzhou Machine Vision Application Engineering Technology Research Center, Xuzhou, China

[a]E-mail: dangpaper@163.com

Keywords: Two-dimensional Fuzzy Entropy; Edge detection; Genetic Algorithm; Threshold

Abstract. The weld image acquisition is generally under the environment of arc, soot and other complex, weld image edge detection is more difficult, this paper proposes a new two-dimensional fuzzy entropy extraction algorithm. When dealing with image edge detection, using the genetic algorithm to obtain the global optimal solution of the edge, the algorithm calculate the two-dimensional fuzzy entropy threshold, thereby which avoid the need large amount of calculation. The simulation results show that the genetic algorithm' convergence to the optimal threshold, near won greatly reduce the running time, detection of weld edge image clearer, achieve the desired effect.

Introduction

As the visual sensor, the image processing algorithms and the development of intelligent control technology, using the optical visual sensing of weld tracking technology obtained the rapid development of weld edge is the basis of the seam tracking and quality control of welding process. In the process of welding, image sensors by arc and other factors, such as dust and noise interference, makes the conventional image processing result is not stable, so improve the weld edge detection precision has very important significance. Weld edge is the most important characteristics of weld image, realize the weld edge detection has been a hotspot of research on image processing, people expect to find a kind of strong noise, positioning, not leak, not mistakenly identified on the edge of the method. The method currently applied to weld image edge detection is operator[1,2] edge detection method (Roberts operator, Sobel operator, log operator, Prewitt operator, Canny operator) ,morphological method[3], etc[4,5]

The fuzzy entropy method is used to measure the size of the image segmentation ambiguity, the image which is segmented by the fuzzy entropy contain the size of the original image information. In the actual image, due to the interference of noise or in the case of image contrast is not obvious, the distribution of the object and background with overlapping and indistinguishable, the distribution of the gray-level histogram image may not appear obvious bimodal or multimodal features, and therefore often get satisfactory segmentation effect, sometimes appear obvious segmentation error.

Two－dimensional Fuzzy Entropy

The previous method only use the image pixel gray level information, and not make full use of all the useful information in the image. A improvement of the problem which the space of the image information is introduced, the increase of image pixel point features, so as to construct a two-dimensional histogram. Objects and background in a two-dimensional histogram will be easier distinguished than in one-dimensional histogram. We know that each pixel in image and the correlation between neighborhood pixels is very big, make full use of the gray level information and spatial information of image segmentation will improve the effect of image edge detection.

The two-dimensional gray histogram was constituted by each pixel gray value and its neighborhood grayscale average. Assuming a grayscale image I gray-scale series for L ,its size is $M*N$. $I_{mn}(m=1,2,..M, n=1,2,..N)$ said coordinates of pixel gray value (m,n) .Set T neighborhood average image is $3*3$ in the image I , and The I and T can form a binary set

$(I,T)=\{(I_{mn},T_{mn})\}_{M*N}$, assuming that the "bright" area $Block_B$ is divided into the fuzzy region B_1 and fuzzy region B_2, namely:

$$Block_B = B_1 \cup B_2$$

$$\begin{aligned} B_1 &= \{(I_{mn},T_{mn}) \mid \mu_{bright}(I_{mn},T_{mn})=1, \\ &\quad (I_{mn},T_{mn}) \in Block_B\}; \qquad (1) \\ B_2 &= \{(I_{mn},T_{mn}) \mid \mu_{bright}(I_{mn},T_{mn})<1, \\ &\quad (I_{mn},T_{mn}) \in Block_B\} \end{aligned}$$

Assume that the "dark" area $Block_D$ is divided into the fuzzy region D_1 and fuzzy region D_2, namely:

$$Block_D = D_1 \cup D_2$$

$$\begin{aligned} D_1 &= \{(I_{mn},T_{mn}) \mid \mu_{dark}(I_{mn},T_{mn})=1, \\ &\quad (I_{mn},T_{mn}) \in Block_D\} \qquad (2) \\ D_2 &= \{(I_{mn},T_{mn}) \mid \mu_{dark}(I_{mn},T_{mn})<1, \\ &\quad (I_{mn},T_{mn}) \in Block_D\} \end{aligned}$$

Above the formulas ,The μ_{bright} is the target membership function and the μ_{dark} is background membership function for and background can be respectively defined as:

$$\mu_{bright}(I_{mn},T_{mn}) = \begin{cases} 0 & others \\ \dfrac{\mu_{bright}(I_{mn};\mathrm{a}_1,\mathrm{c}_1)}{2} + \dfrac{\mu_{bright}(I_{mn};\mathrm{a}_2,\mathrm{c}_2)}{2} & (I_{mn},T_{mn}) \in B_2 \\ 1 & (I_{mn},T_{mn}) \in B_1 \end{cases} \quad (3)$$

$$\mu_{dark}(I_{mn},T_{mn}) = \begin{cases} 0 & others \\ \dfrac{\mu_{dark}(I_{mn};\mathrm{a}_1,\mathrm{c}_1)}{2} + \dfrac{\mu_{dark}(I_{mn};\mathrm{a}_2,\mathrm{c}_2)}{2} & (I_{mn},T_{mn}) \in D_2 \\ 1 & (I_{mn},T_{mn}) \in D_1 \end{cases} \quad (4)$$

Above the formulas, $[a_1,c_1]$ is the original image fuzzy interval, $[a_2,c_2]$ is bounded domain average image fuzzy interval.

The Two—dimensional Fuzzy Entropy is defined as:

$$\begin{aligned} H &= H(Block_B) + H(Block_D) \\ &= -P(Block_B)\log P(Block_B) \\ &\quad - P(Block_D)\log P(Block_D) \qquad (5) \end{aligned}$$

: $P(Block_B) =$

$$\sum_{(s,t)\in Block_B} \mu_{bright}(s,t) \frac{n_{st}}{\sum_{(s,t)\in Block_B} n_{st}}$$

$P(Block_D) =$

$$\sum_{(s,t)\in Block_D} \mu_{dark}(s,t) \frac{n_{st}}{\sum_{(s,t)\in Block_D} n_{st}}$$

Above the formulas, s is two-dimensional gray histogram value and n_{st} is total number of pixel of neighborhood grayscale mean .Based on maximum fuzzy entropy criterion, When the optimal combination

$(\mathrm{a}_{1opt},\mathrm{c}_{1opt};\mathrm{a}_{2opt},\mathrm{c}_{2opt})$ of the fuzzy parameters was search, In order to makes the maximum H.

Set the best segmentation threshold (s_{opt}, t_{opt}) then

$$s_{opt} = (a_{1opt} + c_{1opt}) / 2;$$
$$t_{opt} = (a_{2opt} + c_{2opt}) / 2 \qquad (6)$$

Aim at the characteristics of selection segmentation threshold maximum fuzzy entropy algorithm , standard genetic algorithm (ga) properly was improved , to achieve the purpose of further improving the efficiency of segmentation.

Calculate the Threshold Based on the Genetic Algorithm

GA is put forward by American scientists Holland, which mimic natural biological evolution process and formed a kind of parallel search optimization algorithm, it will be, the biological evolution principle of survival of the fittest, superior bad discard is introduced into the optimization problem. Let groups remain high fitness individuals, through genetic evolution unceasingly, until meet certain termination conditions, so as to get the global optimal solution, its main advantage is simple, strong robustness, needs to solve the more complex problems, the target is not clear, the superiority, the greater the genetic operations mainly includes three basic selection, crossover and mutation operation.

The algorithm steps are as follows:

(1) The population initialization and coding

In random search space ,The N individuals is as the initial population, due to the encoding parameter is a_1, c_1, a_2, c_2, take range for $(0, 255)$, so the members of the chromosome coding into a 32-bit binary string, a_1, c_1, a_2, c_2 can be expressed in 8 bit binary number respectively;

(2) Fitness function

The two-dimensional fuzzy entropy is fitness function (the formula (5)), According to individual fitness value calculated in sorting, take the maximum value, will be the biggest fitness individuals, the groups of the best individual unconditionally copied to the next generation of new groups, and then using the roulette method as the method, selecting fitness of individual choice, and thus be heredity to the next generation, on the contrary, small fitness of individual choice, will be eliminated.

(3) Genetic algorithm parameter

Use genetic algorithm to the following parameters: the group size is set to 100-150, The evolution algebra is 40-100, The crossover rate was $P_c = 0.5$. From the new generation,Groups randomly selected the $[\frac{P_c * N}{2}]$ string single-point crossover operation in single point crossover operation, for each pair of string randomly select a boundary position, and then exchange of the two string of all characters from the beginning to the boundary position, to generate two new string. (4) Termination conditions

If meet the evolution algebra,then turn to terminate, currently has the largest fitness individuals for optimal solution. (5) Decoding

The threshold was confirmed and then the image was segmented.

The Experimental Results and Analysis

As shown in Fig. 1, the original weld image was grayed, in order to verify the validity of the algorithm in this paper, the experimental that the traditional Canny edge detection method,and the genetic algorithm, calculate the maximum fuzzy entropy threshold method to weld after the pretreatment of image edge detection, treatment effect is shown in Fig. 2 and Fig. 3. From the Fig. 2, The traditional Canny edge detection operator can be seen is strongly influenced by noise, and thus has not on the weld image edge extraction of false edges, especially in the internal seam, produced some of the "bubbles", this is very bad for subsequent processing. And can be seen in Fig.3, the proposed method detect the false edge around the weld less, positioning precision, less noise, false edge of weld inside have no spare, get ideal weld edge.

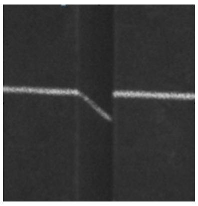

Fig.1 Original Seam image

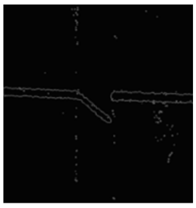

Fig.2 Canny method

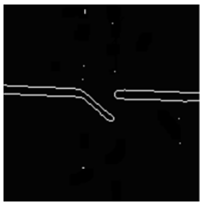

Fig.3 The proposed method

Conclusion

The most important feature of the paper method, is the novelty of two-dimensional maximum fuzzy entropy threshold method based on the genetic algorithm for weld image edge extraction, it can effectively avoid interference in the process of detecting the weld edge, The experiment proved that weld edge continuity is better and accurate result of positioning, pseudo edge is less, so the precision of the weld edge extraction is benefit to subsequent seam image feature points made good foundation.

References

[1]S.Tingzhi,F.ziwen."Image processing and pattern recognition ".beijing, Beijing institute of technology press,1998.128-135.

[2]Z.M.Xie,X.D.Gao. "Edge detection of weld image based on Canny operator", Transactions of the china welding institution, Vol . 27,pp.29-32,36.

[3]H.Wang,B.Wang. "Ray weld defect detection method based on the morphological structure elements ",NDT, Vol. 35,pp. 18-21.

[4]K.Meng,S.B.Cheng."Weld Seam Edge Detect ion Based on Composite Edge Detectors", Journal of shanghai Jiaotong University,Vol.43,pp693-696.

[5]Y.H.Gan,X.Z.Dai. "Application of wavelet edge detection in image processing of welding seam", J.H uazhong Univ.of Sci.&Tech. Vol.36,pp. 65-67,86.