Studentská konference Fakulty mechatroniky, informatiky a mezioborových studií
7. červen 2012, Liberec, Česká republika

Using of Fuzzy Technologies for Image Processing

TECHNICKÁ UNIVERZITA V LIBERCI
Fakulta mechatroniky, informatiky a mezioborových studií

Bc. Ondřej Kašpar
Ing. Jaroslav Vlach, PRECIOSA, a.s.
Ústav řízení systémů a spolehlivosti

Abstract

The diploma thesis deals with application of fuzzy logic in image processing especially the edge detection of objects in the image. The thesis hereby suggests a new approach to the edge detection in image processing. The main task is design and implementation of the fuzzy edge detector in MATLAB and LabVIEW. The goal is testing of the fuzzy edge detector on the jewelry stone images and result comparison with "classical" edge detectors. The emphasis lays on time efficiency and visual results.

Goals

- Design and implementation of the fuzzy edge detector in MATLAB and LabVIEW
- Implementation of "classical" edge detectors in MATLAB
- Testing of the fuzzy edge detectors on the jewelry stone images
- Comparison with the "classical" edge detectors (visual results and time efficiency)

Fuzzy logic theory

In a classical set theory, an element either does or doesn't belong to the set. For example the number two belongs fully to the set of even numbers and not at all to the set of odd numbers.

In fuzzy sets it is different. Object belongs only partially to a fuzzy set. It can also belong to more than one set. Every object belongs to the set with fuzzy degree <0,1>. The only constrain of fuzzy logic that the objects degree of membership in complementary must sum to the unity. For example water is 60 percent cold and 40 percent not cold (Fig. 1).

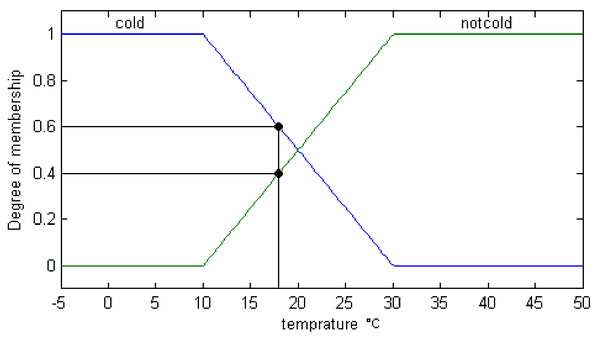

Fig. 1. Fuzzy logic (water temperature)

Fuzzy Inference System

Fuzzy Inference System (FIS) is a way of mapping from a given input to an output with using fuzzy logic. In fact, a FIS consist of four modules. Fuzzification module transforms inputs to the fuzzy sets. The input is always a crisp value. The main task is to determine the degree to which inputs belong to the fuzzy sets using of membership functions. Expert knowledge stores the set of IF-THEN rules. Inference engine simulates the human reasoning process by making fuzzy inference on inputs and IF-THEN rules. Input to the defuzzification module is the fuzzy set obtained from the inference engine and output is a crisp value.

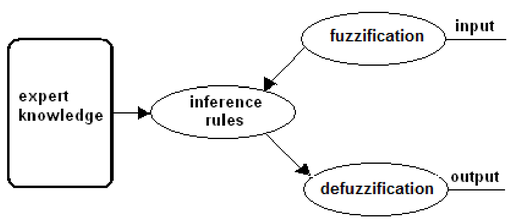

Fig. 2. Fuzzy Inference System (FIS)

Fuzzy edge detection

I have made three fuzzy edge detectors. One of them was made with 2x2 sliding window mask. Because of a small window mask this algorithm is relatively fast and very simple. The rest two algorithms were made with 3x3 window mask. First of them was made according to literature suggested rules [2] and it has not had precise results. Algorithm has some problems with detecting of diagonal edges. For this reason I have implemented another fuzzy detector with 3x3 window mask (improved algorithm). I added four more rules and the results are superior to the previous algorithm. Fuzzy sets for inputs and output are displayed in the Fig. 3

All my algorithms were implemented in MATLAB with using of Fuzzy Logic Toolbox and in LabVIEW with using of Fuzzy Logic Toolkit for implementation of Fuzzy Inference Systems.

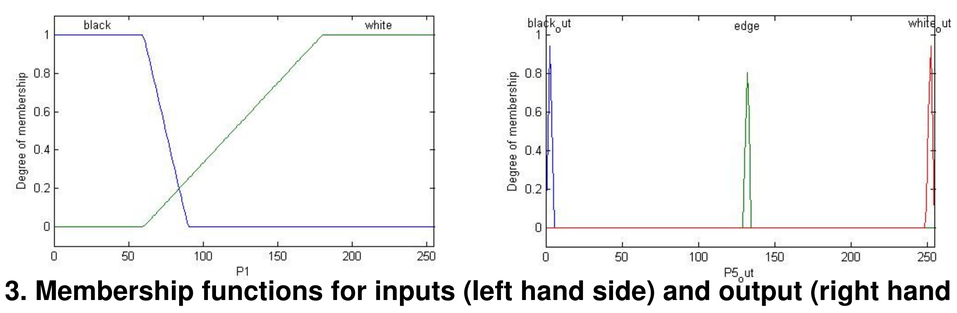

Fig. 3. Membership functions for inputs (left hand side) and output (right hand side)

Algorithms efficiency and visual results

Time efficiency of the fuzzy edge detectors is more than hundred times worse than the classical edge detectors. Time for execution of the classical edge detectors is less than one second. Fuzzification and defuzzification are relatively difficult operations and their realizations are time consuming. Also using of toolboxes (in MATLAB and LabVIEW) is slower in any case. For this reason I have made simple fuzzy edge detectors. I skipped fuzzification and deffuzification part. I used only the middle part of Fuzzy Inference System which uses IF-THEN rules. This algorithm has the best time efficiency of all algorithms which I have made. Time for execution of this algorithm is almost immeasurable. It is about 0.01 second. Visual results are shown in the pictures bellow.

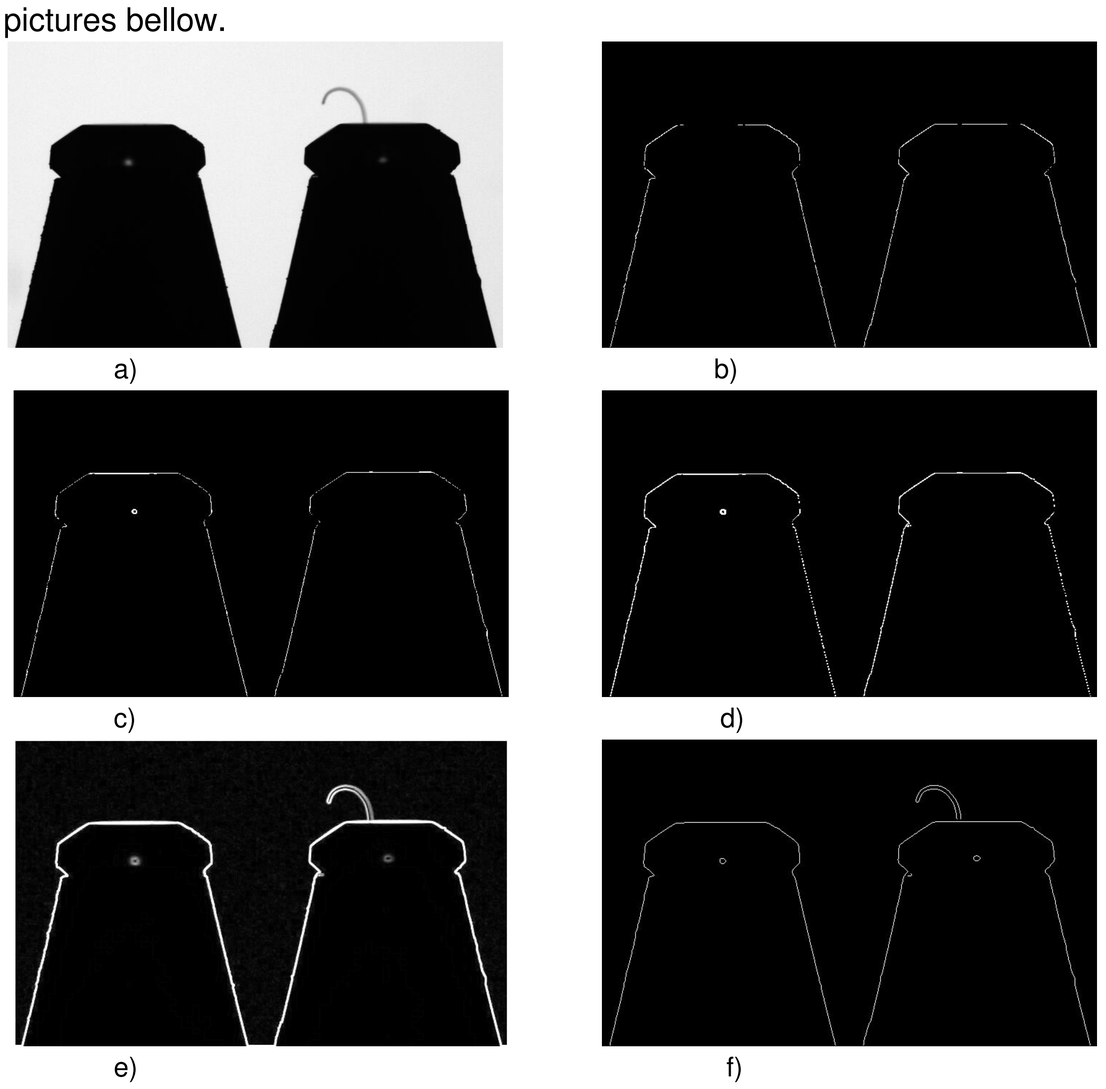

Fig. 4. Visual results of the edge detectors. a) Original image, b) Fuzzy edge detector with 2x2 sliding window in MATLAB, c) Fuzzy 3x3 improved algorithm in LabVIEW, d) Fuzzy simple algorithm 2x2, e) Sobel filter, f) Canny detector

Conclusion

Fuzzy edge detectors very reliably detect edges of the object. Their advantage is detection without any preprocessing, but drawback is big time consuming with using of toolboxes from MATLAB or LabVIEW. For this reason the edge detection using fuzzy logic in MATLAB or LabVIEW is not suitable for real time image processing which has to be used in Preciosa Company. One possibility for decreasing of the execution time would be implementation of FIS on my own.

Classical algorithms also precisely detect all edges but unwanted objects are also considered as an edge. This is possible to eliminate with some preprocessing. For example morphological closing can eliminate unwanted objects on the top of the detected stone.

References

[1] Novák, V.: Fuzzy množiny a jejich aplikace, SNTL Praha 1986
[2] Alshennawy, A.A., Aly, A.A.: Edge Detection in Digital Images Using Fuzzy Logic Technique, Vol. 5, No. 4, 2009, p. 264-269. Available at www: http://www.waset.org/journals/waset/v51/v51-30.pdf
[3] Sonka, M. – Hlavac, V. – Boyle, R.: Image Processing, Analysis, and Machine Vision, Thomson Learning, Toronto 2008

Contact

Bc. Ondřej Kašpar, E-mail: kaspar.ondrej1@gmail.com

Prezentace teto práce byla podpořena z projektu SGS 2012.