Adaptive IR and VIS image fusion

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Introduction

The adaptive image fusion system based on neural network principle was realized. It works with digitalized video sequences of visible and infrared band sensors, and is able to produce the optimal fused image for a wide range of lighting conditions through an adaptive change of a fusion algorithm.

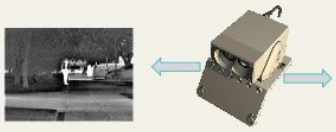
The change is driven by a change in the measured statistic of the input images. The best algorithm for a particular input is found with the help of an objective measurement of the fusion process quality.

VIS and IR images capturing

Thermal Eye/X-50

uEye/Sun Star 300

IR video signal is interpolated to VIS signal resolution



VIS video signal is rescaled to IR signal field of view

The hardware of our fusion system consists of infra and visible light sensitive cameras, the grabber card MPX-6864 and the Intel board D525MW with the processor 1.8 Ghz. The OS Ubuntu11 drive the whole system and the library Gstreamer is used to perform a fusion part. The resolution of a fused video signal is 640x480px. The system deals with a paralax problem.

Simple fusion algorithms

Limited computation capabilities of the system hardware along with the 25Hz repetition rate requirement limit the system to work with very simple fusion algorithms only. Three pixel level algorithms were tested.

1) Maximum rule (MAX)

$$F(m,n)=\max(I_{VIS}(m,n),I_{IR}(m,n))$$

2) Alpha mixing (MIX)

$$F(m,n)=\alpha(m,n)I_{VIS}(m,n)+(1-\alpha(m,n))I_{IR}(m,n)$$

$$\alpha(m,n)=\frac{\sigma_{VIS}(m,n)}{\sigma_{VIS}(m,n)+\sigma_{IR}(m,n)}$$

3) VIS contrast enhancing[1] (CON)

$$F(m,n)=I_{VIS}(m,n)^{(1-I_{IR}(m,n))}$$

Objective measurement of the fusion process quality

The objective metrics proposed by Piella[2] was applied for fusion algorithms perfmormation evaluation. The core of the method lies in evaluating structural similarity index between two images:

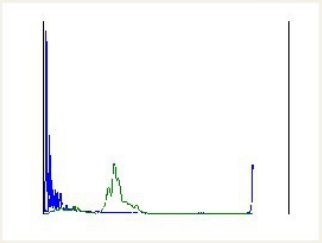
$$SSIM(a,b)=\frac{4\sigma_{ab}\bar{a}\bar{b}}{(\bar{a}^2+\bar{b}^2)(\sigma_a^2+\sigma_b^2)}$$

Fusion quality with the help of index $\lambda_{VIS}(w)=\frac{\sigma_{VIS}}{\sigma_{VIS}+\sigma_{IR}}$ is then defined:

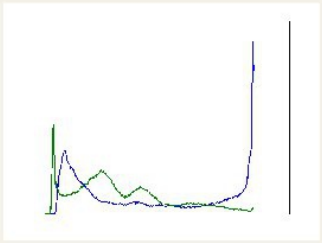
$$Q(VIS,IR,F)=\frac{1}{|W|}\sum_{w\in W}(\lambda_{VIS}(w)SSIM(VIS,F|w)+\lambda_{IR}(w)SSIM(IR,F|w))$$

Examples of the input images statistics

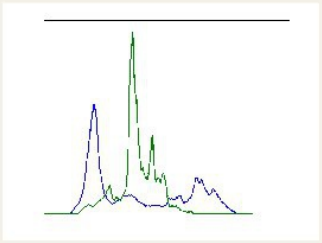
Histograms of input images can be classified into different groups according to their shapes and VIS and IR histograms correlation. A preferred fusion algorithm exists for each group as the objective metrics evaluation shows This fact was used for designing a neural network algorithm.



Q = MAX: 0.77 MIX: 0.77 CON: 0.39



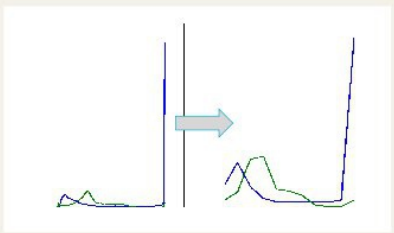
Q = MAX: 0.61 MIX: 0.66 CON: 0.58



Q = MAX: 0.37 MIX: 0.55 CON: 0.64

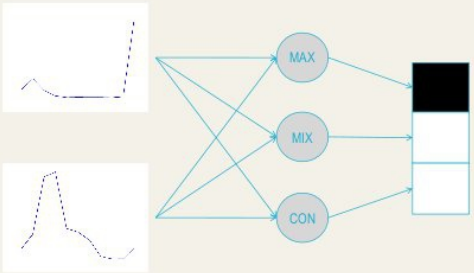
Input patterns

Simplified versions of the input images histograms are used as inputs for the neural network. The original histograms are binned to eleven parts . Such a data serves as input pattern.



Neural Network

The artificial neural network was trained to predict the best fusion algorithm for input histograms patterns. The classification style network was used.



The input layer has 22 nodes, 11 for each histogram pattern. The output layer has 3 nodes, one for each fusion algorithm. Output values should be 1 or 0 (use or not use the particular algorithm). This 3 numbers form an output pattern.

Conclusion

The adaptive fusion system of VIS and IR images was realized. The system switches between three simple fusion algorithms and the change is driven by coarse-grained histograms of images. The classification neural network was used as a basic concept. Outputs of the proposed system and a multiresolution algorithm on a testing data set were compared. Ability of our adaptive system to deliver comparable outputs as much more time consuming multiresolution method was proven.

Adaptive system

$Q_{average}$ = 0.69

Multiresolution algorithm

$Q_{average}$ = 0.73

References

1) Liu, Z., Laganiére, R., Contex enhancement through infrared vision: a modified scheme, SIVIP 1:293-301 (2007)

2) Piella, G., New quality measures for image fusion, Proceeding of the Seventh International Conference on Information Fusion 542-546 (2004)

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