Center for Optical Technologies

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Image Fusion and Image Quality Metrics for Night Vision Application

Project Title: Image Fusion

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http://www.eecs.lehigh.edu/SPCRL/spcrl.htm

Introduction

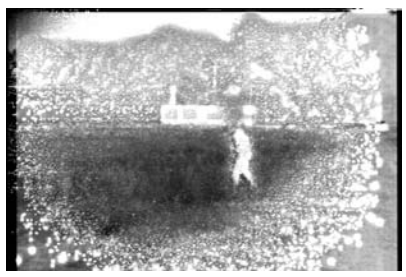
Objective

- Evaluate various fusion algorithms for night vision application
- Investigate existing quality measures for image fusion
- Develop new statistical approach (image quality metric)

Image Fusion Algorithms Evaluation

Eliminate the method with poor performance

Contrast Pyramid



RoLP Pyramid

Fusion schemes to be evaluated

Fusion Scheme	MSD level	Activity Measure	Grouping	Combining	Weights(IITV/IR)	Verification
ADD	None	None	None	None	70%/30%	None
DWT1	4	Coefficient based	None	Weighted Average	70%/30%	None
LAP1	4	Coefficient based	None	Weighted Average	70%/30%	None
FSD1	4	Coefficient based	None	Weighted Average	70%/30%	None
GRAD1	4	Coefficient based	None	Weighted Average	70%/30%	None
MORPH1	4	Coefficient based	None	Weighted Average	70%/30%	None
SiDWT1	4	Coefficient based	None	Weighted Average	70%/30%	None
DWT2	4	Coefficient based	None	Choosing Maximum	None	None
LAP2	4	Coefficient based	None	Choosing Maximum	None	None
FSD2	4	Coefficient based	None	Choosing Maximum	None	None
GRAD2	4	Coefficient based	None	Choosing Maximum	None	None
MORPH2	4	Coefficient based	None	Choosing Maximum	None	None
SiDWT2	4	Coefficient based	None	Choosing Maximum	None	None

Human evaluation experiment and results

- All the fused images generally provide improved situational awareness over either source image
- With respect to contrast, MDB fusion with choosing maximum rule better than weighted average combining rule
- FSD and gradient fusion perform similarly
- Morphological fusion has too many artifacts
- SiDWT, DWT, and Laplacian pyramid with choosing max perform better than others

Objective Image Quality Evaluation

Existing image quality measures

- Standard deviation (SD)
- Entropy (EN)
- SNR estimation (QS)
- Cross entropy (CE)
- Information based measure (MI)
- Objective edge based measure (QE)
- Universal index based measure (UI)

Objective evaluation results

Fusions	SD	EN	QS	CE	MI	QE	UI
Additive	36.4290	6.6368	15.4075	1.6008	**0.9626**	0.5123	0.7532
DWT1	38.9434	6.8680	14.5335	1.6482	0.5813	0.5981	0.7525
LAP1	40.2345	6.8927	14.8446	1.6015	0.6007	0.6287	0.7691
FSD1	36.4459	6.7232	14.2176	**1.6763**	0.6610	0.5921	0.7675
GRAD1	36.4199	6.7206	14.2362	**1.6657**	0.6665	0.5989	0.7705
MORPH1	42.3541	6.9710	15.3862	1.3877	0.5703	0.5653	0.7096
SiDWT1	39.0756	6.8329	14.7015	**1.6614**	0.6203	**0.6394**	0.7717
CONTR1	45.1546	6.2915	16.8178	1.2113	0.5876	0.4731	0.6276
RoLP1	43.7580	6.9225	**16.9766**	1.4984	0.5695	0.4014	0.6405
DWT2	47.0168	**7.1646**	14.1588	1.5010	0.8292	0.6099	0.7729
LAP2	47.6479	**7.1451**	14.4417	1.2690	**0.8748**	**0.6417**	**0.7919**
FSD2	43.8442	7.1106	13.3304	1.4394	0.7420	0.6081	0.7816
GRAD2	43.8315	7.1088	13.3601	1.4377	0.7454	0.6146	**0.7847**
MORPH2	**49.0287**	**7.2369**	15.1978	1.3227	0.8711	0.5943	0.7538
SiDWT2	47.3851	7.1109	14.2546	1.3090	**0.8930**	**0.6505**	**0.7954**
CONTR2	**58.1269**	6.4099	**17.8570**	1.1822	0.4952	0.3783	0.5259
RoLP2	**51.1613**	6.6568	**17.5098**	1.6077	0.5938	0.3880	0.5831

- Based on 28 sets of night vision images
- QE metric shows close relation to the evaluation ratings from observers
- MI and UI match the observers' evaluations in some cases but with exceptions
- SD, EN, QS, and CE no apparent correlation to human perceptual evaluations

New Image Quality Metric

Motivation

- Edges correspond to object boundaries changes and contain useful information
- Preliminary studies show edge intensity based quality metric matches human evaluation
- Certain objects of interest in the image are more important

Schemes

- Statistical deformable template models is utilized to incorporate prior knowledge about the image scene and to describe the shape of object
- Model parameters are estimated by maximizing a likelihood function
- The likelihood function is directly related to the strength of the edges of objects
- A larger likelihood value is considered to indicate a better fused image quality