



Universiteit
Leiden
The Netherlands

Content-based retrieval of visual information

Oerlemans, A.A.J.

Citation

Oerlemans, A. A. J. (2011, December 22). *Content-based retrieval of visual information*. Retrieved from <https://hdl.handle.net/1887/18269>

Version: Corrected Publisher's Version

[Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

License: <https://hdl.handle.net/1887/18269>

Note: To cite this publication please use the final published version (if applicable).

Content-Based Retrieval of Visual Information

Ard Oerlemans

Content-Based Retrieval of Visual Information

PROEFSCHRIFT

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden
op gezag van de Rector Magnificus prof. mr. P. F. van der Heijden,
volgens besluit van het College voor Promoties
te verdedigen op donderdag 22 december 2011
klokke 10.00 uur

door

Adrianus Antonius Johannes Oerlemans

geboren te Leiderdorp
in 1977

Promotiecommissie

Promotor:	Prof. dr. J.N. Kok
Co-promotor:	Dr. M.S. Lew
Overige leden:	Prof. dr. C. Djeraba (University of Lille)
	Prof. dr. T.H.W. Bäck
	Prof. dr. H.A.G. Wijshoff
	Dr. E.M. Bakker

The cover of this thesis consists of images from the MIRFLICKR-25000 dataset. Each column represents the top results of a color-based query using a specific wavelength of light as the query.

Contents

1	Introduction	1
1.1	Content-based image retrieval	3
1.2	Research areas in CBIR	5
1.2.1	Image segmentation	5
1.2.2	Curse of dimensionality	5
1.2.3	Semantic gap	6
1.2.4	Searching with relevance feedback	6
1.2.5	Future CBIR challenges	6
1.3	Thesis contents	7
2	Features	9
2.1	Introduction	9
2.2	Color features	10
2.2.1	Color histogram	10
2.2.2	Color moments	10
2.3	Texture features	11
2.3.1	Local binary patterns	11
2.3.2	Symmetric covariance	11
2.3.3	Gray level differences	12
2.4	Feature vector similarity	12
3	Machine Learning	15
3.1	Introduction	15
3.1.1	A sample binary classification problem	16
3.2	k -nearest neighbor	16
3.3	Artifical neural networks	17
3.4	Support vector machines	18
4	Performance Evaluation	21
4.1	Precision	21
4.2	Recall	22
4.3	Precision-Recall graphs	22

4.4	Average precision	25
4.5	Accuracy	26
5	Interest Points Based on Maximization of Distinctiveness	27
5.1	Introduction	27
5.2	Related work	28
5.3	Maximization Of Distinctiveness (MOD)	28
5.3.1	The MOD paradigm	29
5.3.2	The special case of template matching	30
5.3.3	Detector output	31
5.4	Matching images	36
5.5	Experiments and results	36
5.6	Discussion and conclusions	39
6	Learning and Visual Concept Detection	41
6.1	Introduction	41
6.2	Related work	43
6.3	Maximization Of Distinctiveness (MOD)	43
6.4	Detecting visual concepts	43
6.4.1	Classifiers	44
6.5	Experiments	44
6.5.1	Tree detection	46
6.5.2	Building detection	46
6.5.3	Sky detection	48
6.5.4	Beach classification	49
6.5.5	Face detection	49
6.6	Experiments on MIRFLICKR-25000 dataset	51
6.6.1	Concept 'Animals'	52
6.6.2	Concept 'Indoor'	54
6.6.3	Concept 'Night'	56
6.6.4	Concept 'People'	58
6.6.5	Concept 'Plant life'	60
6.6.6	Concept 'Sky'	62
6.6.7	Concept 'Structures'	64
6.6.8	Concept 'Sunset'	66
6.6.9	Concept 'Transport'	68
6.6.10	Concept 'Water'	70
6.6.11	Overall results	72
6.7	Discussion, conclusions and future work	72
7	Multi-Dimensional Maximum Likelihood	75
7.1	Introduction	75
7.2	Definitions	76
7.3	Detailed description	76

7.4	Related work	78
7.5	Multi-Dimensional Maximum Likelihood similarity (MDML)	79
7.6	Experiments on stereo matching	80
7.6.1	Results - template based	80
7.6.2	Results - pyramidal template based	80
7.7	Future work	83
8	Texture Classification: What Can Be Done with 1 or 2 Features?	85
8.1	Introduction	85
8.2	Related work	86
8.3	Our method	86
8.4	Results	88
8.5	Discussion, conclusions and future work	90
9	Detecting and Identifying Moving Objects in Real-Time	93
9.1	Introduction	93
9.2	Related work	94
9.3	Motion detection	94
9.3.1	Building the background model	95
9.3.2	Adaptive background model	97
9.3.3	Post processing	98
9.4	Object tracking	98
9.4.1	Data structure	99
9.4.2	Object motion prediction	100
9.4.3	Rule-based object tracking	101
9.5	Results	105
9.6	Conclusions and future work	106
10	Hybrid Maximum Likelihood Similarity	109
10.1	Introduction	109
10.2	Related work	110
10.3	Visual similarity	110
10.3.1	The maximum likelihood training problem	110
10.3.2	Hybrid maximum likelihood similarity	111
10.4	Relevance feedback in object tracking	111
10.4.1	Pixel-level feedback	112
10.4.2	Object-level feedback	113
10.5	Conclusions and future work	114
A	RetrievalLab	117
A.1	Introduction	117
A.2	Related work	117
A.3	Example usage	118
A.3.1	Image retrieval	118

A.3.2 Visual concept detection	120
A.4 Discussion, conclusions and future work	121
Bibliography	123
Nederlandse Samenvatting	131
Acknowledgements	135
Curriculum Vitae	137