



Universiteit
Leiden
The Netherlands

Pattern Recognition in High-Throughput Zebrafish Imaging

Nezhinsky, A.E.

Citation

Nezhinsky, A. E. (2013, November 21). *Pattern Recognition in High-Throughput Zebrafish Imaging*. Retrieved from <https://hdl.handle.net/1887/22286>

Version: Corrected Publisher's Version

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

Downloaded from: <https://hdl.handle.net/1887/22286>

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

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/22286> holds various files of this Leiden University dissertation

Author: Nezhinsky, A.E.

Title: Pattern recognition in high-throughput zebrafish imaging

Issue Date: 2013-11-21

PATTERN RECOGNITION IN HIGH-THROUGHPUT ZEBRAFISH IMAGING

A.E. Nezhinsky

ISBN: 978-94-6191-966-3

PATTERN RECOGNITION IN HIGH-THROUGHPUT ZEBRAFISH IMAGING

Proefschrift

ter verkrijging van

de graad van Doctor aan de Universiteit Leiden,

op gezag van Rector Magnificus prof. mr. C.J.J.M. Stolker,

volgens besluit van het College voor Promoties

te verdedigen op donderdag 21 November 2013

klokke 10.00 uur

door

Alexander E. Nezhinsky

geboren te Leningrad, USSR in 1982

Promotiecommissie

Promotor:

Prof. Dr. J. N. Kok

Co-promotor:

Dr. Ir. F. J. Verbeek

Overige leden:

Prof. Dr. T. Bäck

Prof. Dr. W. Bitter

Prof. Dr. H. P. Spaink

Dr. W. A. Kusters

The studies described in this thesis were performed at the Leiden Institute of Advanced Computer Science and supported by the SmartMix Programme of the Netherlands Ministry of Economic Affairs and the Netherlands Ministry of Education, Culture and Science.

Contents

1	Introduction	9
1.1	Whole Mount High Throughput Screening	9
1.1.1	Non-Vertebrate Models	10
1.1.2	Vertebrate Models	11
1.2	Pattern Recognition	12
1.3	Outline of the Thesis	13
1.3.1	Image Processing and Segmentation	14
1.3.2	Analysis of Statistics of Patterns	14
2	Segmentation and Pattern Recognition in Image Space	17
2.1	Introduction	18
2.1.1	Related Work	18
2.1.2	Overview of Basic Approaches for Zebrafish Embryo Segmentation	20
2.1.3	Deformable Template Matching	24
2.2	Deformable Template Matching (Approach 1)	24
2.2.1	Method	24
2.2.2	Optimization by a Genetic Algorithm	26
2.2.3	Multiple Object Recognition	29
2.2.4	Experiments	30
2.2.5	Conclusions and Discussion	32
2.3	Deformable Template Matching (Approach 2)	33
2.3.1	Method	34
2.3.2	Application to the Zebrafish Larvae Images	38
2.3.3	Experiments and Results	40
2.3.4	Conclusions	42
3	Anchor Region Based Pattern Recognition in Image Space	45
3.1	Introduction	46
3.1.1	Related Work	46
3.1.2	Algorithm Overview	48
3.1.3	Pre-processing	49
3.2	Pattern Recognition: The Anchor Region Based Method	51
3.2.1	Prototype Template	51
3.2.2	Conversion from Image to Graph	53
3.2.3	Bayesian Formulation	61
3.2.4	Finding an Optimal Solution	63

3.3	Case Study 1: Zebrafish infection analysis	64
3.3.1	Zebrafish Orientation	65
3.3.2	Zebrafish Region Annotation	66
3.3.3	Data	66
3.3.4	Analysis and Results	66
3.4	Case Study 2: Other Model Organisms	68
3.5	Conclusions	70
4	Software Development and Evaluation for High Throughput Zebrafish Analysis	73
4.1	Introduction	74
4.2	High Throughput Experiments	74
4.2.1	Image Acquisition	74
4.2.2	Data Storage	75
4.2.3	User Analysis	76
4.3	Our Approach	76
4.3.1	Workflow	76
4.3.2	Components	78
4.4	Evaluations and Results	82
4.4.1	User Evaluations	82
4.4.2	Results	83
4.4.3	Performance Evaluations and Results	83
4.5	Conclusions and Discussion	87
5	Data and Pattern Analysis in Infection Studies in Zebrafish	89
5.1	Introduction	90
5.2	Analysis of High Throughput Zebrafish Infections Screens Based on Approach 2	91
5.2.1	Brightfield Imaging: Shape Localization and Annotation	92
5.2.2	Fluorescent Imaging: Analysis	93
5.2.3	Output and Dataset Creation	93
5.2.4	Analysis and Results	94
5.2.5	Conclusions	99
5.3	Analysis of High Throughput Zebrafish Infections Screens Based on Approach 3	100
5.3.1	Analysis and Results	102
5.4	In Depth Analysis of High Throughput Zebrafish Infections Screens	107
5.4.1	Experiments	107
5.4.2	Analysis and Results	107
5.4.3	Total amount of Infection	107
5.4.4	Amount of Infection separated into Regions	113
5.4.5	Infection Flow per Mutant Strain	118
5.4.6	Average Size of Clusters	120
5.5	Conclusions	124

6 Discussion	125
6.1 Pattern Recognition in Computer Vision	126
6.2 Software Development	127
6.3 Statistical Analysis	127
6.4 Conclusion	129
Bibliography	131
Dutch Summary	137
Russian Summary	141
Curriculum Vitae	143
List of publications	145
Acknowledgements	147

