

A New Image-Mining Technique for Automation of Parkinson's Disease Research

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Outline

1 Introduction

- Parkinson's Disease Research
- Model Filling Problem

2 The Proposed Technique and Algorithmic Scheme

- The Technique and Scheme Description
- Image Processing and Analysis
- Analysis of Proposed Method

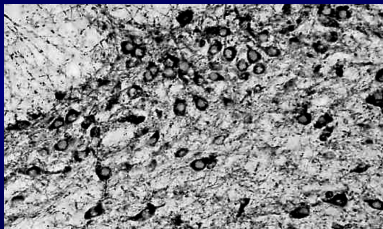
3 Investigation of Parkinson's Disease Model

- Experimental and Control Groups Differences Detection
- Construction of Object Representations and Clustering

4 Conclusion

Initial Data

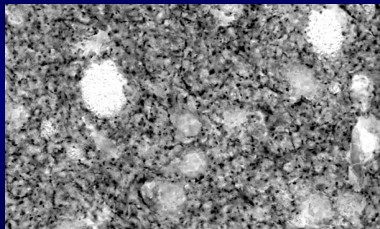
The **initial data is digital images** of the immunostained sections of various brain areas.



Neurons

- 1 The **resolution** of initial images is $0.0117 \mu\text{m}^2/\text{pixel}^2$.
- 2 Terminals are rounded objects with **area varying from** $0.6 - 0.7 \mu\text{m}^2$ **up to** $2.5 - 3 \mu\text{m}^2$.

Experimental data have been received from digital images of distal parts of axons.



Terminals

Automation of Parkinson's Disease Model Research

- The problem —
 - the **development and study** of suitable **mathematical technique** for **automated extraction and characterization** of objects in brain section images;
 - the implementation of the technique as an **efficient algorithmic scheme** and **software**.
- The approach — joint use of:
 - image processing and analysis techniques of **mathematical morphology**;
 - mathematical theory of **pattern recognition**;
 - **Descriptive Approach** to image analysis.

Scheme Description

The developed algorithmic scheme consists of the following stages:

- 1 **preprocessing**: 1.1) opening by reconstruction; 1.2) the bot-hat transformation by dual reconstruction; 1.3) closing by dual reconstruction; 1.4) h-dome elimination transformation;
- 2 **image analysis**: 2.1) object and background markers extraction; 2.2) morphological gradient image modification; 2.3) watershed segmentation;
- 3 **construction of object representations**: 3.1) construction of feature descriptions (25 morphometric, densitometric and textural features are used); 3.2) feature selection;
- 4 **classification**: 4.1) objects clustering; 4.2) results interpretation.

Image Processing and Analysis

Preprocessing and image analysis stages of the scheme are based on the mathematical morphology theory.

High efficiency of the developed technique is caused by:

- 1 computational efficiency of implementation of morphological operators;
- 2 selected sequence (combination) of transformations;
- 3 the ordering of used structuring elements.

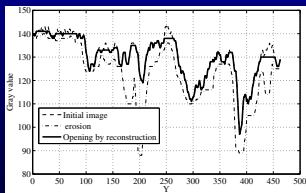
Application of this stages of the scheme to initial images enables:

- to smooth complex background;
- to detect small objects on images;
- to eliminate out-of-focus objects;
- to separate close objects.

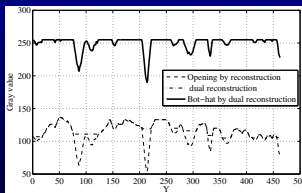
Step 1 – 3 (Main Contribution)

Application of these steps in such a **sequence** with appropriate **ordered** structuring elements $B_i, i = 1, \dots, 3$ ($B_3 \prec B_1 \prec B_2$) allows us to extract only those **dark structures** that satisfies to allowable interval of **area variation**.

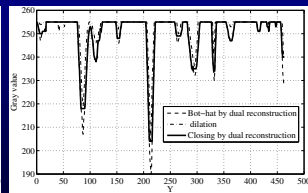
Plots of Intensity function



Step 1. Elimination of initial image narrow peaks corresponding to the background.

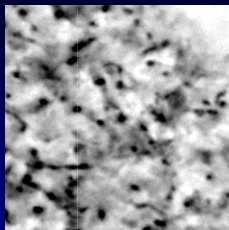


Step 2. Correction of complex heterogeneous background on the initial image.

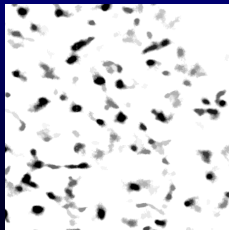


Step 3. Nonuniform regions smoothing in the interior of the terminals.

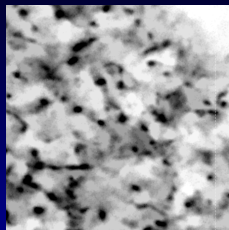
Step 1.1 – 2.1 (Illustration of Transformations)



Initial



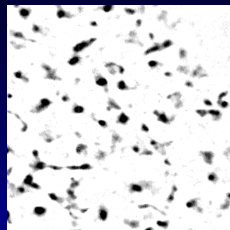
Step 1.3



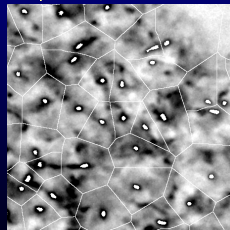
Step 1.1



Step 1.4

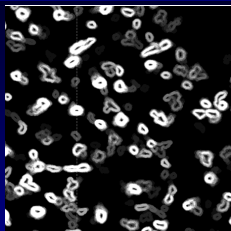


Step 1.2

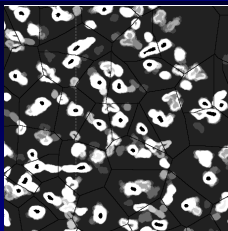


Step 2.1

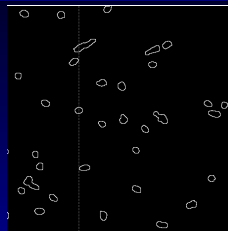
Step 2.2 – 3.1 (Illustration of Transformations)



Gradient



Step 2.2

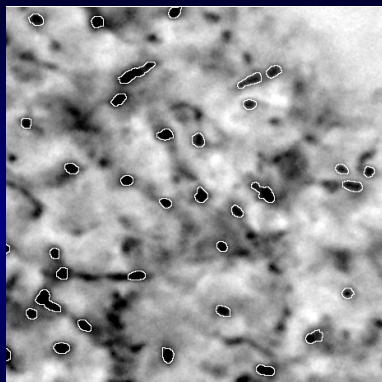


Step 2.3

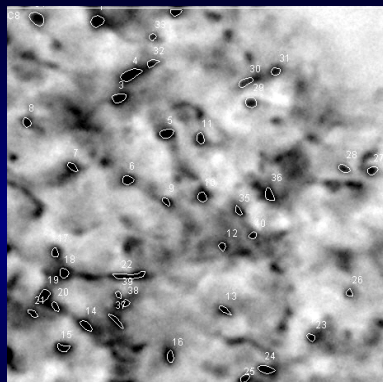
Table: Object feature list (Step 3.1)

No	Morphometric features			Densitometric features		
	Perimeter μm	Area μm^2	Elongation	Min	Mean	Max
1	4.87	1.71	1.05	68	80.25	92
...
1664	4.59	1.41	1.82	89	103.79	116

Visual Comparison of Automatically and Manually Selected Objects



Automatic extraction



Manual extraction

Results

- 1 We proposed new technique and created on its base the **algorithmic scheme for automated extraction of data** for construction and investigation of Parkinson's disease experimental model.
- 2 Experimental **investigations** of the scheme confirmed:
 - **possibility and suitability** of striatum frontal section images **automated processing and analysis**;
 - the **precision** of the results is **comparable (non less than)** with that of manual object feature estimation.
- 3 Experimental **applications** of the developed technique confirmed its **high efficiency**:
200 times increase in productivity and **10 times decrease in the amount of experimental animals and expendables.**