Level set method for cell image segmentation

Krzysztof Voss[1]

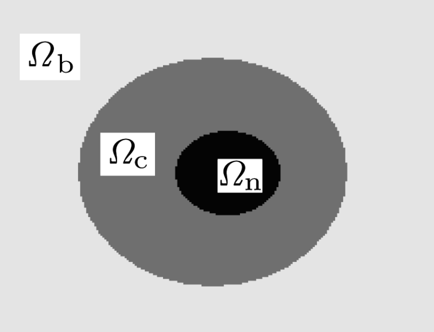
University of Saskatchewan

November 29, 2011

[1] kmv633@mail.usask.ca

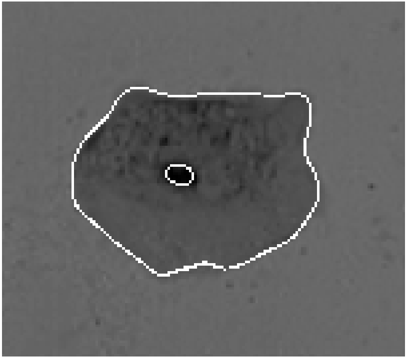
Table of contents

Cell structure



Source: [1]

Goal



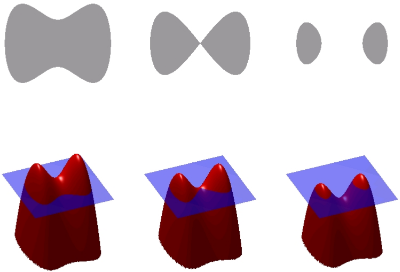
Processed imgage from [1]

Paper

Solution by Ma Jing-feng *et al.* [1].

- One level set function
- Proper initialization
- Eliminating factor - a priori knowledge
- Improved speed

Illustration



Source: Wikimedia Commons Author: Olegalexandrov

Evolution equation

$$
\begin{aligned}
\frac{\partial \phi}{\partial t} = & -\delta_\epsilon(\phi)(\lambda_1 e_1 - \lambda_2 e_2) \\
& + \upsilon \delta_\epsilon(\phi) \operatorname{div}\left(\frac{\nabla \phi}{|\nabla \phi|}\right) \\
& + \mu \left(\nabla^2 \phi - \operatorname{div}\left(\frac{\nabla \phi}{|\nabla \phi|}\right)\right) \\
& - \eta \delta_\epsilon(\phi) \| I(x) - R_c \|^2
\end{aligned}
$$

Source: [1]

Data fitting

Driving the active countour towards object boundaries

$$e_i(x) = \int K_\sigma(y-x)\,|I(x) - f_i(y)|^2\,\mathrm{d}y, \quad i = 1, 2.$$

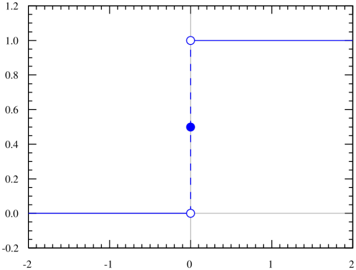
$$f_i(x) = \frac{K_\sigma(x) * [M_i^\epsilon(\phi(x))I(x)]}{K_\sigma(x) * [M_i^\epsilon(\phi(x))]}, \quad i = 1, 2.$$

$$M_1 = H(\phi), \quad M_2 = 1 - H(\phi)$$

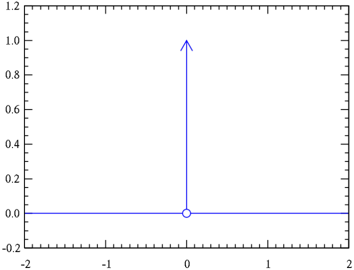
Source: [1]

Heaviside Functions

Heaviside
$H(x)$



Dirac Delta
$H'(x) = \delta(x)$



Source: Wikimedia commons

Intensity distance

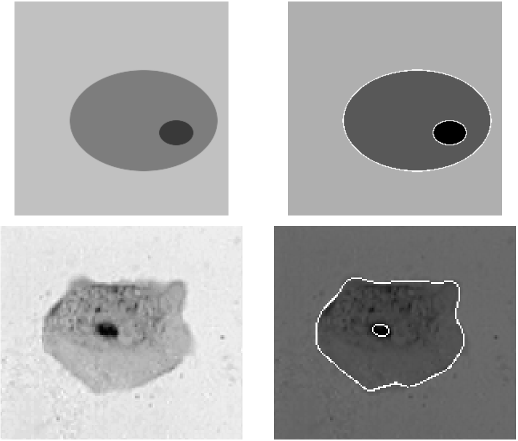
$$\|I(x) - R_c\| = \begin{cases} I(x) - R_{max}, & \text{if } I(x) > R_{max}, \\ 0, & \text{if } R_{max} > I(x) > R_{min}, \\ R_{min} - I(x), & \text{if } R_{min} > I(x). \end{cases}$$

Source: [1]

Libraries

- NumPy - http://numpy.scipy.org/
- SciPy - http://www.scipy.org/
- Matplotlib - http://matplotlib.sourceforge.net/
- Mahotas - http://luispedro.org/software/mahotas
- PythODE [2]

Results



Source of real cell image: [1]

References

Ma Jing-Feng, Hou Kai, Bao Shang-Lian, and Chen Chun.
A new level set model for cell image segmentation.
Chinese Physics B, 20(2), February 2011.

Andrew Kroshko.
Integrating-factor-based 2-additive Runge-Kutta methods for advection-reaction-diffusion equations.
Master's thesis, University of Saskatchewan, 2011.