Level Set Method, Image Processing and Deep Learning

Myungjoo Kang
Department of Mathematical Sciences, Seoul National University, Seoul 151-742, KOREA

ABSTRACT

Since 1990, many mathematicians studied the levelset method, the image processing based on partial differential equations and variational methods. The levelset method was one of the main technique to make real scenes in the movie. For the image processing research, there were a lot of improvement using TV(total variation) and some optimization techniques. But suddenly deep learning method comes out to us, and it turns out to be the Method to solve many very difficult or unsolved problems. I will give a talk about the theories and applications of the levelset method, image processing and deep learning.

INTRODUCTION

(a) Level Set methods.
(b) PDE based image processing method.
(c) Deep learning techniques
(d) Applications

Mathematicians Go Hollywood

This new framework was introduced in 1997 by Stanley Osher and James Sethian. Since then it has been a thriving topic of research. Just know that their seminal paper in 1997 has been cited more than 13,300 times! Level set methods have been applied to an incredible variety of problems and settings: medical imaging, computer vision, image denoising, active contour segmentation, stroke extraction, and much more. It has been widely explored both theoretically and numerically. One of the richest areas of application is computer graphics. One of their students, Dan Fedkiw, now full professor at Stanford, won an Academy Award and Technical Award in 2000. Fedkiw is a consultant for "Inception" and "Inception 2." He worked on blockbusters like "Poseidon" and "The Matrix" and is a key player in the field of computer graphics.
**The Mumford-Shah Model**

- **The Mumford-Shah Model** \((87)\)

\[
\inf_{u,C} F(u,C) = \mu \text{length}(C) + \lambda \int_{\Omega} |u - u_0|^2 \, dx \, dy + \int_{\Omega - C} |\nabla u|^2 \, dx \, dy
\]

- **u**: the optimal approximation of \(u_0\), smooth outside the edges \(C\)
- **C**: the set of discontinuous or edges of \(u\)

- **Difficulties**
  1. dimension of \(C\) < dimension of \(u\)
  2. \(F\) : non-convex
  3. shortage of differentiability
     - cannot use the Euler–Lagrange equation
  4. very complex to discretize \(C\)

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**Applications of Deep Learning**

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**REFERENCES**
