Lake Monitoring using Satellite Image based on Deformable model

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Presentation Layout

- Objective
- Motivation
- Loop holes of existing system
- Proposed system
- Conclusion
Objective

- Design of a lake monitoring system using satellite images.
- Extracted water covered region image can be used to
  - planning efficient water use
  - expanded or destroyed based on time series
- Integrate Structural and spatial Knowledge
  - texture and spectral information
- Design pixel-by-pixel with high accuracy image segmentation
Motivation

- Lake monitoring from remotely sensed images has always been a challenging problem.

- One of the main sources which can capture the temporal nature of the knowledge is the satellite image.

- Sensors that provide fine spatial resolution data for automated feature extraction.

- Accurate knowledge on water covered region information is essential for
  - GIS databases,
  - Water usage planning,
  - emergency response applications.
Motivation

• Since mankind is able to take pictures from outer space, it has always been a difficult task to recognize specific patterns, related to a special problem.

• As computer science raised a stadium where computers are able to perform some "intelligent" tasks, a wide research area established in solving the problem of lake monitoring system.

• Satellite Image Classification and boundary extraction
  - assessment of different land cover types over a certain geographic region and to determine its extent
Loop holes of Existing System

• Various work has not yet proved in a completely satisfactory way the competitiveness of satellite based methods compared with ground measures and aerial surveys.

• The water coverage assessment using satellite image to get sub-pixel accuracy.

• Geospatial database embedding water covered region
Proposed system

The proposed methodology has been broadly divided into four steps:

• Image Classification
• Nearest neighborhood grouping (NNG)
• Deformation Method
• Performance Evaluation
• The image used is a high resolution satellite image of the urban Bangalore area in Karnataka, India. It has dimensions of 897 x 561 pixels.

• By setting the threshold value 0.95, the high resolution image was grouped into 50 clusters in an unsupervised classification, five of which corresponds to water region.

• A few cases of misclassification of water to roads and vegetations were also seen.
Result – Image Classification

- Vegetation-Trees
- Vegetation-Grass
- Water
- Road
- Urban
- Shadow
- Bare Ground
**Nearest Neighborhood Grouping (NNG)**

- A nearest neighborhood grouping (NNG) operation is applied to the classified image.
- Smoothes the spectral response within the pixel’s local neighborhood.
- In this process the small patches of water contrast abnormalities are eliminated.
Results - NNG
Deformation Method

• Deformation models are curves or surfaces of objects defined within an image domain that can move under the influence of internal forces and external forces.

• The design of internal forces is to keep the model smooth during deformation whereas an external force is to move the model toward an object boundary.

• Since deformable models are implemented on the continuum, the resulting boundary representation can achieve sub-pixel accuracy.

• There are basically two types of deformable models:
  - Parametric Deformable Model (PDM) and
  - Geometric Deformable Model (GDM).

• Snake and Level set algorithm are the type of formulation for PDM and GDM respectively.
**Parametric Deformation Method: Snake**

• The snake-based contour extraction is that the search for a contour is focused by specifying snake’s initial position as a parametric curve.

• Contour is said to possess energy ($E_{snake}$) which is defined as the sum of the two energy terms.

  $$E_{snakes}(v) = E_{int}(v) + E_{ext}(v)$$

• $E_{int}$ represents the internal energy to smooth the shape of curve,

  $$E_{int}(v) = \frac{1}{2} \int \alpha(s) \left| \frac{\partial v(s, t)}{\partial s} \right|^2 + \beta(s) \left| \frac{\partial^2 v(s, t)}{\partial s^2} \right|^2 ds$$

• $E_{ext}$ represents external energy to match the image features such as strong edges

  $$E_{ext}(v) = \int_{0}^{l} P(v(s, t)) ds$$
Results - Snake

Extracted water regions using Snake
Geometric Deformation Model: Level Set Evolution

- Allows automatic topology changes, merging and breaking.

- The level set method will continue to propagate towards the boundary based on inflating pressure force (inside the object) and deflating pressure force (outside the object).

- For the water cover mapping problem, it is desirable for pressure force to be less than or greater than zero, surrounding the edges of the true water covered region.
Geometric Deformation Model: Level Set Evolution

2-phase segmentation
1 level set function

initial(LSM)= \[
\begin{cases}
  \text{if } c > 0; & \text{inflateLSM} \\
  \text{else if } c < 0; & \text{deflateLSM} \\
  \text{else if } c = 0; & \text{on the object boundary}
\end{cases}
\]
Level Set Evolution

- Image $u_0 : \Omega \to \mathbb{R}$
- evolve a curve $C$ to detect objects in $u_0$
- the curve has to stop on the boundaries of the objects

$$\mathcal{E}(\phi) = \mu P(\phi) + \mathcal{E}_{g,\lambda,\nu}(\phi)$$

-The external energy $E_{g,\lambda,\nu}$ drives the zero level set toward the object boundaries,
-The internal energy $\mu P(\phi)$ penalizes the deviation of from a signed distance function during its evolution.
Extracted water regions using LSM-Deflate
Results – Level Set Method

Extracted water regions using LSM-Inflate
From the ground truth, ulsoor lake is spread over 0.5001 sq km

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Deformation method</th>
<th>Deformation algorithm</th>
<th>Area of water coverage in Sq km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parametric</td>
<td>Snakes</td>
<td>0.4199</td>
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<tr>
<td>2</td>
<td>Geometric</td>
<td>Level set method using deflate</td>
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<tr>
<td></td>
<td></td>
<td>Level set method using inflate</td>
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Conclusions

• In this paper we present lake monitoring using satellite image to detect the area of water covered region using parametric and geometric deformation method for high resolution imagery.

• Classification based on the unsupervised approach resulted in a satisfactory extraction of water region.

• The Snake and level set method (inflate and deflate) helped to detect water cover mapping.

• We have shown that the model is robust and it is able to retrieve water coverage region in any image samples.

• Initial results are indeed very promising and indicate robust modeling capability to retrieve automatically the water distributed area.
Thank You