

Master Thesis Outline TQET33

The Institute of Technology at Linköping University

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1 Introduction

This master thesis will be carried out at Vricon. Supervisor at Vricon is Anton Nordmark, supervisor at ISY is Martin Danelljan and the examiner is Fahad Khan at ISY.

1.1 Contact Information

Anton Nordmark: anton.nordmark@vricon.com

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2 Preliminary Title

A preliminary title for the master thesis is *Texture and Color Based Classification of Clouds in Satellite Images using SVM*.

3 Problem Formulation

The aim of this thesis is to evaluate methods to segment satellite images into cloud and non-cloud pixels, and compare the result to Vricon's inhouse methods. Different combinations of existing methods for feature extraction and classification will be evaluated.

4 Approach

A preliminary approach for solving the task is to divide the problem into several smaller problems. Each subproblem is described in more detail in the subsections below. The pipeline can be seen in figure 1 below.

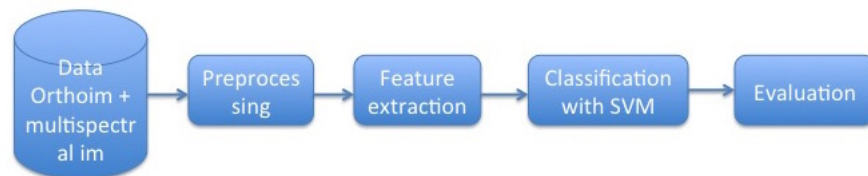


Figure 1: Pipeline

4.1 Data

The images that will be used for cloud classification in this thesis is both panchromatic high resolution images, and also an eight-band multispectral imagery, containing various types of landscape and cloud amount. All images will be provided by Vricon. These images will be used to create feature vectors of training data.

4.2 Pre processing

To make the classification easier the images are pre processed. This will be done by tiling the images into smaller tiles. An alternative to tiling is to do a superpixel segmentation that will be taken into consideration. Also, a histogram equalization will be applied. This will flatten the greylevel histogram of the image so that all intensities are as equal as possible and thereby the image contrast is increased.

4.3 Feature Extraction

After the pre processing is done it is time to perform the feature extraction. A good feature clearly separates the two classes from each other. Texture and color are the two features that will receive the biggest focus in this master thesis. Some suggestions for features extractions to test are:

- Gabor Filters:

A set of Gabor filters with different frequencies and orientation might be good to extract texture features from the clouds. The equation for a complex Gabor filter looks like follows:

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = e^{-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}} e^{i(2\pi \frac{x'}{\lambda} + \psi)} \quad (1)$$

where

$$x' = x \cos \theta + y \sin \theta$$

and

$$y' = -x \sin \theta + y \cos \theta$$

- Homogeneous Texture Descriptor:

Clouds have a very homogeneous texture, so the Homogeneous Texture Descriptor (HTD) might be good to extract texture features in the clouds. It is based on computing the local spatial-frequency statistics of the texture.

- Grey level co-occurrence matrix:

A grey level co-occurrence matrix (GLCM) is a histogram of co-occurring greyscale values at a given offset over an image. The GLCM functions characterize the texture of an image by calculating how often pairs of pixels with specific values and in a specified spatial relationship occur in an image.

- Color:

Since the clouds often differ in color compared to other areas with similar texture (for example water) it might be good to use color as an feature for the classification.

Additional features that is discovered during the work might be tested as well.

4.4 Classification

For the classification Support Vector Machines (SVM) will be used. SVM is a supervised learning method. Consider a set of *training* vectors $\mathbf{x}_i, i = 1, \dots, k$, which are the feature vectors, and the corresponding vector \mathbf{y} of length k containing the class values;

$$y_i = \begin{cases} 1, & \text{if } \mathbf{x}_i \text{ in class 1} \\ -1, & \text{if } \mathbf{x}_i \text{ in class 2} \end{cases} \quad (2)$$

Then we have the separating hyperplane as $\mathbf{w}^T \mathbf{x} + b = 0$

$$\begin{cases} (\mathbf{w}^T \mathbf{x}_i) + b > 0 & \text{if } y_i = 1 \\ (\mathbf{w}^T \mathbf{x}_i) + b < 0 & \text{if } y_i = -1 \end{cases} \quad (3)$$

The decision function then becomes $f(\mathbf{x}) = \text{sgn}(\mathbf{w}^T \mathbf{x} + b)$, where \mathbf{x} is the testdata. There are many possible choices for \mathbf{w} and b . Equation 3 can be rewritten as

$$y_i(\mathbf{w}^T \mathbf{x}_i + b) \geq 1, \text{ for all } 1 \leq i \leq k \quad (4)$$

which gives an optimization problem:

$$\min_{\mathbf{w}, b} \frac{1}{2} \mathbf{w}^T \mathbf{w} \quad (5)$$

subject to (for any $i = 1, \dots, k$)

$$y_i(\mathbf{w}^T \mathbf{x}_i + b) \geq 1$$

If the data is not linearly separable it can be mapped to a higher dimensional feature space using the Kernel trick: $K(\mathbf{x}_i, \mathbf{x}_j) = \phi(\mathbf{x}_i)^T \phi(\mathbf{x}_j)$ where

$$\phi(\mathbf{x}_i) = (\phi_1(\mathbf{x}_i), \phi_2(\mathbf{x}_i), \dots)$$

The new equation is:

$$\begin{aligned} \min_{\mathbf{w}, b, \xi} \frac{1}{2} \mathbf{w}^T \mathbf{w} + C \sum_{i=1}^k \xi_i \\ \xi_i \geq 0, i = 1, \dots, k \end{aligned} \quad (6)$$

subject to (for any $i = 1, \dots, k$)

$$y_i(\mathbf{w}^T \phi(\mathbf{x}_i) + b) \geq 1 - \xi_i$$

Some common kernels that will be tested during this thesis are:

- Linear Kernel: $K(\mathbf{x}_i, \mathbf{x}_j) = \mathbf{x}_i \cdot \mathbf{x}_j$
- Polynomial Kernel: $K(\mathbf{x}_i, \mathbf{x}_j) = (\gamma \mathbf{x}_i \cdot \mathbf{x}_j + r)^d, \gamma > 0$
- Gaussian Radial Basis Function: $K(\mathbf{x}_i, \mathbf{x}_j) = e^{(-\gamma \|\mathbf{x}_i - \mathbf{x}_j\|)^2}, \gamma > 0$
- Sigmoid Kernel: $K(\mathbf{x}_i, \mathbf{x}_j) = \tanh(\gamma \mathbf{x}_i \cdot \mathbf{x}_j + r)$

4.5 Post processing

After the classification is done some post processing might need to be implemented to clean up some of the wrongly classified objects. For example a shape based post processing can be used to remove objects that are to "perfect" from the cloud class.

4.6 Evaluation

When the classification is done the result needs to be evaluated to know how the algorithm performed. This will be done by comparing the classified images to a hand labeled ground truth. Some ground truth already exists, and some might need to be hand labeled during the thesis.

5 Time Plan

The given task has been divided into several sub tasks to easier plan the work. The estimated time for each sub task is listed in the time plan in figure 2 below. Note that week 53-2 and week 11-12 are marked red because of Christmas break and exams.

5.1 Dates

- Half-time Control: February 3, 2016.
- Presentation: April 20, 2016.

ACTIVITIES		Time Plan, week number																												sum
Nr	Description	45	46	47	48	49	50	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	sum		
Writing Planning Report		7	9	9																								25		
1	Literatur study	33	30	20	10																							93		
3	Preparatory work			5	9	10																						24		
5	Pre- and postprocessing			5	10	8	10	8	5				4	3	3	2	2	2	2									68		
7	Feature extraction				5	5	10	8	5				8	8	8													57		
8	Classification					4	5	8	5				8	9	9	8	8	5	6									75		
	Code Documentation												5	8	7	9	5	3	2	2			5	5				51		
9	Evaluation					5	5	6	4				5	7	8	5	8	9	9	6			15	15				107		
10	Writing Thesis Report				5	7	9	9	4				9	4	4	15	16	20	20	29			19	10		4		164		
11	Presentation																							9	31	20		60		
	Opposition																											40		
12	Meeting Supervisor																											18		
13	Sum (h)	40	40	40	40	40	40	40	24	0	0	0	40	40	40	40	40	40	40	40	0	0	40	40	32	24	40	800		
15	Thesis Outline			18/11																										
16	Half Time Control												32																	
	Thesis Report first draft																		9/3											
17	Thesis Report																						6/4							
18	Presentation																									20/4				

Figure 2: Time Plan

6 Literature

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