Tree Species Classification Using Radiometry, Texture and Shape Based Features

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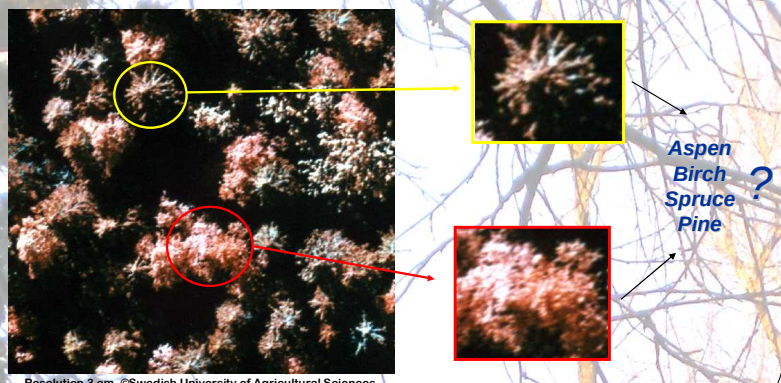
Problem

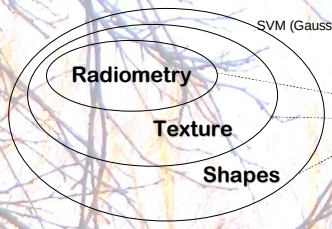
To classify into species the tree crowns selected from high resolution Colour InfraRed aerial images, using radiometry, texture and crown shape based features.



Resolution 3 cm, ©Swedish University of Agricultural Sciences

Classification Steps

Feature creation ····· **Classification results**



performances:
- maximum $P_{\max}$
- average P

confusion matrices

Comparison

Feature creation and Classification

Data: N=48 selected crowns (12 per class)

Training set: 24 (6 per class) randomly chosen crowns

Evaluation of the SVM classifier :

- average performance of experiments:

$$P = \Big(\sum_{i=1}^{N_c} P_i - \sum_{w=1}^{N_w} P_w - \sum_{b=1}^{N_b} P_b\Big)/(N_e - N_w - N_b)$$

Performance of one experiment, $P_i = N_c / N$ (Number of correctly classified crowns)

Highest 5% and lowest 5% of experiment performance values

Number of experiments minus 10%

- maximum performance $P_{\max}$
- confusion matrix

(aspen (*a*), birch (*b*), spruce (*c*), pine (*d*))

1.Radiometry based features

First order statistics: the mean and standard deviation computed from the histogram of pixel intensities on the image

Confusion matrix:

$$\begin{bmatrix} 0.5 & 0.5 & 0 & 0 \\ 0.167 & 0.666 & 0.167 & 0 \\ 0 & 0.334 & 0.666 & 0 \\ 0 & 0 & 0.167 & 0.833 \end{bmatrix} \begin{matrix} a \\ b \\ c \\ d \end{matrix}$$

$P = 0.54$

$P_{\max} = 0.67$

2. Texture based features

Energy and Contrast extracted from 9 grey level co-occurrence matrices (GLCM a compact representation of pairs of pixel values) with a distance d=1 and 135 degree direction :

$$\sum_{i=1}\sum_{j=1} P_d^{\,2}(i,j)$$

$$\sum_{i=1}\sum_{j=1} (i-j) P_d^{\,2}(i,j)$$

Confusion matrix:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0.833 & 0 & 0.167 \\ 0.334 & 0 & 0.666 & 0 \\ 0 & 0 & 0.167 & 0.833 \end{bmatrix} \begin{matrix} a \\ b \\ c \\ d \end{matrix}$$

$P = 0.71$

$P_{\max} = 0.83$

3.Shape based features

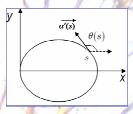
Tree crown contours are continuous and closed curves

$$\alpha = (\alpha_1(s), \alpha_2(s)) : |\alpha'(s)| = 1$$

The curves are represented by their *angle functions* $\theta(s)$ $\forall s \in [0,2\pi]$

$$\theta = \theta_0 + f, \quad f \in L^2 \quad \text{and} \quad \theta_0(s) = s \quad \text{is a unit circle}$$

$$\theta \in C \subset \theta_0 + L^2, \quad \text{with } \textit{C shape space (Klassen et al.)}$$



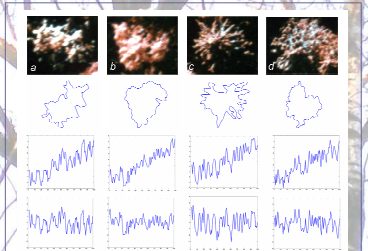
$$\alpha'(s) = e^{j\theta(s)}$$

Invariance of angle function to rigid rotation and translation, and to scaling

$$\frac{1}{2\pi}\int_0^{2\pi}\theta(s)ds = \pi \qquad \int_0^{2\pi} e^{j\theta(s)}ds = 0 \qquad \int_0^{2\pi} ds = 2\pi$$

$$\phi^1 = \frac{1}{2\pi}\int_0^{2\pi}\theta(s)ds, \phi^2 = \int_0^{2\pi}\cos(\theta(s))ds, \phi^3 = \int_0^{2\pi}\sin(\theta(s))ds$$

$$\phi = (\phi^1, \phi^2, \phi^3) \Rightarrow \boxed{C = \phi^{-1}(\pi, 0, 0)}$$



Examples of crowns of four species, their contours, corresponding $\theta(s)$ and $\theta = \theta' - \theta_0$ at the bottom

Features:

Crown contours are approximated by ordered collection of points $p_t, t = 1..n$

Geodesic distance to circle $v_c(\theta) = d(\theta_i, \theta_0)$

Contour elasticity $v_e(\tilde{\theta}) = \int_0^{2\pi} \tilde{\theta}^2(s)ds$, where $\tilde{\theta}(s) = \theta(s) - \theta_0(s)$

Number of branches/convexities $v_N(\tilde{\theta}) = N$, with local maxima number N of $\tilde{\theta}(s)$

Size of crown contour irregularities: $v_\mu(\tilde{\theta}) = \mu = \sum_{k=1}^{n} |\tilde{\theta}(s_k)|$, with $s_k = \sum_{t=1}^{k} c_t$; $c_t = \|p_{t-1} - p_t\|$

$$v_{Var}(\tilde{\theta}) = Var = \frac{1}{n-1}\sum_{k=1}^{n}\left(\mu - |\tilde{\theta}(s_k)|\right)^2$$

$$v_d(\tilde{\theta}) = \{d^1{}_{\min}(h_l), l = 1,\ldots,N_l\}, \quad \text{where}$$

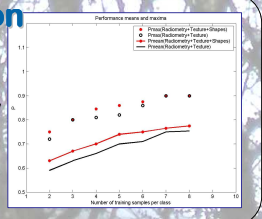
$$d^1{}_{\min}(h_i) = \min\{d_{\min}(h_i, h_j)\}^{j=1,\ldots,m_l}, \quad d(h_1(x), h_2(x)) = \sqrt{< h_1(x), h_2(x) >},$$

$$h_{\tilde{\theta}}(x) = card\{\tilde{\theta}(s) = x, s \in [0,2\pi]\}, x \in R\}, \quad i = 1,\ldots,N \quad \text{and}$$

m_l number of examples per class l

Conclusion

Incorporating of shape features allows to improve by about 4% the performance mean and maximum



Confusion matrix:

$$\begin{bmatrix} 0.833 & 0.167 & 0 & 0 \\ 0.167 & 0.833 & 0 & 0 \\ 0 & 0.167 & 0.833 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} a \\ b \\ c \\ d \end{matrix}$$

$P = 0.747$

$P_{\max} = 0.875$