Detection of buildings through multivariate analysis of spectral, textural, and shape based features

Thomas Knudsen
National Survey and Cadastre (KMS)
Geodetic Department
8 Rentemestervej
DK-2400 Copenhagen NV
Email: thk@kms.dk

Allan Aasbjerg Nielsen
Techn. Univ. of Denmark
Informatics and Mathematical Modelling
Richard Petersens Plads, Bldg. 321
DK-2800 Lyngby
Email: aa@imm.dtu.dk

Abstract—In order to facilitate the update of the building theme in photogrammetrically derived GIS databases, we investigate spectral, textural, and shape features of areas of aerial photos previously registered as buildings. In following steps, these features are used in a classification tree characterisation of the entire photo, and a simple classification routine (minimum Mahalanobis distance). The classification results are to be used for (1) verification of the GIS database and (2) change detection for subsequent update work. The classification trees show to be hard to prune (generalize) without large loss of precision. This indicates that the problem at hand is far from trivial: the building and background classes are hard to separate. Hence, the method described here can not stand alone: additional algorithms focusing on different aspects of the problem (and finally combined in a fusion step) could be one way to go; another, technically more promising, but economically less viable, would be to enter high resolution height data, derived from photogrammetry or laser scanning, into the input data set.

I. INTRODUCTION

In recent publications, numerous methods for automated reconstruction/registration of buildings from stereo imagery have appeared (cf. e.g. [1], [2]). A common characteristic of these methods is the requirement of an existing approximate position for the building under registration. In the present work, we outline a method for producing such approximate positions based on sets of true colour (RGB) or colour-infrared (CIR) aerial imagery in combination with prior registrations from a GIS database.

The primary intention with the work is to support the automated update and verification of the building theme in the TOP10DK GIS database [3], which is the primary topographic product of the National Survey and Cadastre—Denmark (KMS). TOP10DK consists of high precision, fully 3D registrations. It was originally created using black and white aerial photogrammetry, and is now maintained using true colour photogrammetry. Colour infrared photogrammetry is under investigation, primarily due to its very good discrimination between vegetation and human made materials.

II. METHOD

The prior registrations from the GIS database are used to derive a training dataset for a multivariate classifier: as TOP10DK is fully 3D, the registrations can be transformed directly into image coordinates using the basic photogrammetric relations. Rather than using the raw photos for the training dataset, we use a version, which is first segmented using the EDISON segmentation algorithm [4]. The original 3 channel dataset is then extended to a 20 channel feature vector for each segment by computing a vegetation index and a set of basic shape and textural parameters.

The a priori assumption is that the vegetation index and texture indices will help remove vegetated background, while the shape based indices will help remove road segments. The feature vectors of the training dataset is then used as input to a classification and regression tree (cf. [5]), in order to get a first impression of the discriminative characteristics of the elements of the (rather heterogeneous) data set.

Finally, the most promising elements are used in a basic minimum distance classification, based on the Mahalanobis distances to (1) the training dataset, and (2) a set drawn from the areas previously registered as non-building.

III. RESULTS & DISCUSSION

The method is based on the assumption that only a limited number of different roofing materials are in common use, and that the number of changes (new buildings and demolitions) is small compared to the number of previous registrations. But even under these assumptions, we expect the most reasonable results in suburban areas, where buildings are typically surrounded by vegetation: vegetation is, especially in the colour-infrared cases, highly suitable for automated detection. In general, the method should only be considered one step in the solution of a complex problem. In a fully operational setup, we expect that multiple methods combined in a final fusion step will be necessary.

Results from 3 test sites (semi-suburban, deep suburban, and university campus) are shown in figures 1–3. Data from both CIR and RGB flights are shown but due to flight characteristics, leading to differences in viewing geometry, the CIR and RGB cases are not exactly overlapping.

Tree based classification: In general, the tree classification routine matches the input data very well, with a misclassification below 3% in all cases. The complexity of the datasets is, however reflected in the number of terminal nodes of
the classification trees, which falls in the range 20–50, with the CIR cases in the lower end. The limited pruning of the trees results in very good redetection of the training dataset, while the detection of additional buildings is only moderately successful.

**Minimum Mahalanobis distance classification:** The (expected) tendency of better separability in the CIR case is also reflected in the MMD discrimination step where, following the indications from the tree classification, the shape based indices have been omitted. Especially in test site 1, the discrimination between buildings and vegetation is very dubious. In test site 3 the major problem is to distinguish between the road/parking lot surfaces and the roofs covered with asphalt roofing felt. In this case it appears that the blue channel from the RGB data actually plays an important role for separability.
IV. CONCLUSION

The classification trees show to be hard to prune (generalize) without large loss of precision. This indicates that the problem at hand is far from trivial: the building and background classes are hard to separate.

Basically, the major problem is the lack of height data in the set of observations—the combination of heights and vegetation indices from CIR photos can result in very efficient building detection. Adding height observations from high-resolution photogrammetry or laser scanning would be the most reasonable solution, from a technological point of view. From an economical point of view, this is however, not viable in an operational setup.

The approach taken here does not depend on any height data, but it can not stand alone: additional algorithms focusing on different aspects of the problem (e.g. detection of shadows) must be included. This also implies that the final classification will require an additional fusion step.
REFERENCES


