URBAN STRUCTURE TYPES - A MEANS FOR CHARACTERIZING AND PARTITIONING URBAN AGGLOMERATIONS WITH A MULTITUDE OF APPLICATIONS

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1. INTRODUCTION

A recently growing number of investigations is dealing with urban structure types (USTs) which are a suitable means for characterizing and subdividing urban agglomerations into meaningful units [e.g., 1, 2, 3]. USTs are defined by specific spatial structures. This means that morphology, amount and arrangement of urban objects (buildings, streets, trees, lawns etc.) are specific and homogeneous within a certain area – the extent of a UST patch. In addition, USTs are defined by a specific land use. The UST concept has a multitude of applications. For instance, it is widely applied for extrapolation of ecological [e.g. 2, 4, 5] as well as socioeconomic [e.g., 6, 7] variables in cases where direct mapping is to costly or impossible. Due to the influence of the structural differences of USTs on the resultant air temperature USTs are also employed as input data for energy models [8]. A special case of UST mapping is the mapping of informal settlements since in this case only one UST is of interest. Successful remote sensing based semi-automatic algorithms have been developed by [e.g., 9, 10, 11] using very high resolution multispectral satellite data.

Several classification schemes for USTs have been developed in different cities, countries and for a multitude of application fields although the authors often use a different terminology (urban structure types [1, 6], urban morphology types [2], urban structural units [3], urban structure units [12]. However, many of the above-mentioned authors conducted the mapping of USTs manually by visual interpretation of aerial photographs. New sensors such as airborne hyperspectral scanners or high resolution spaceborne multispectral sensors in combination with existing GIS data open up the opportunity to develop automatic procedures. However, so far only a few authors have developed automatic or semi-automatic algorithms; in each case using specific UST definitions for a specific field of application and the algorithms were proved based on one city only [1, 9, 13, 14].

Since there is no common standard definition for USTs that would be applicable to all kinds of research questions or applications and to all kinds of urban agglomerations there is a need for a *flexible and adaptable* approach for automatic UST classification based on remote sensing and auxiliary data. In this paper, we therefore identify the commonalities of existing approaches and derive requirements and tasks to deal with in UST classification. Based on this, we focus on the development of a UST classification system that is easily adaptable to different cities and to user-definable USTs and demonstrate its application on three morphologically different cities from different cultural areas of the world.

2. STUDY AREAS AND DATA

Study areas are situated within the cities of Berlin (50.6 km^2 subset) and Dresden (entire city), Germany as well as Padang (entire city), Indonesia. The analyzed data include hyperspectral and multispectral optical high resolution remote sensing data (HyMap, Ikonos), high resolution digital elevation models, and city blocks as auxiliary GIS data.

3. REQUIREMENTS AND TASKS TO DEAL WITH IN UST CLASSIFICATION

UST mapping is conventionally done by visual interpretation of aerial photographs [e.g. 2]. A literature search revealed that all of the few investigations that developed semi-automatic or automatic approaches based on analysis of remote sensing images agree in what is needed to classify USTs: (1) Existing patch boundaries, (2) user-defined thematic categories of USTs, (3) a land cover classification, (4) spatial feature calculations and (5) a UST classifier. However, the approaches differ in their degree of automation and whether certain data or information is generated by the approach itself or taken as auxiliary data from other sources. Furthermore, there are several strategies for the definition of USTs. These issues will be discussed in detail in the final article.

4. DEVELOPED WORKFLOW FOR UST CLASSIFICATION

We present the entire workflow to go through during the application of the developed UST classification system (Fig. 1) based on the three study areas, starting at the collection and preprocessing of remote sensing data, through the calculation of spatial features, the use of a data-driven automatic feature selection routine, and the final application of the UST classifier which is based on pairwise Maximum Likelihood classifications. A huge database of 50 basic spatial features assessing the assemblage of surface cover types and the arrangement of real world objects within the UST patches allows the adaptation of the UST classification system to different cities and different UST definitions. In this context, the automatic feature selection method (Sequential Forward Selection) ensures that classifications always take place in appropriate sub-spaces.

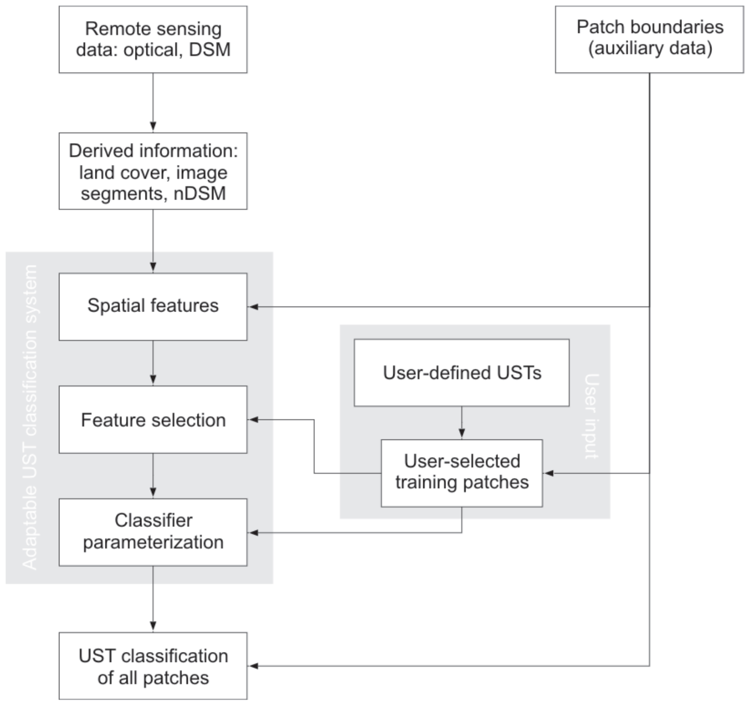

Figure 1. Workflow of UST classification using the developed adaptable UST classification system. DSM = digital surface model, nDSM = normalized digital surface model.

5. RESULTS AND CONCLUSIONS

Classification results will be shown and discussed based on exemplary map details and accuracy assessment. A special emphasis in the discussion of the results will be places on the adaptability of the approach by comparing the results of the three study areas. The conclusions from this work will result in the formulation of issues to be addressed in the future.

6. REFERENCES

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