Algorithms for Automated Extraction of Man-Made Objects from Raster Image Data in a GIS

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Abstract

This paper addresses the topic of semi-automatic object extraction for GIS data capture. It includes novel algorithms and conceptual strategies, together with performed experiments, encountered problems and adopted solutions. In particular, we present an algorithm and obtained results for *semi-automatic extraction of road networks from SPOT imagery* using wavelet-transformed images and cost functions expressing local gray value variations and global continuity constraints. For larger scale images and for various object types, we present our technique of *least squares template matching* for edge extraction, which uses local gray value variations to precisely identify edge locations. Finally, we propose a global approach for *semi-automatic object outline detection,* whereby least squares matching provides the mathematical foundation, while global continuity is enforced through the introduction of object-type-dependent shape constraints.

1 Introduction

Photogrammetric methods are optimal for GIS data capture, providing opportunities for mass production and fast updating. Aiming at the improvement of production rate, digital photogrammetry offers the potential to highly increase the degree of automation of photogrammetric operations. However, and despite the great advancements of the last decade, there lacks an efficient digital photogrammetric strategy to provide both fast and accurately GIS data, which could substitute existing analytical photogrammetric operations. Addressing this issue, we present novel algorithms for automated object extraction intended to function as core modules within the framework of a digital photogrammetric semi-automatic monoplotting strategy for GIS data capture, currently under development in our Institute.

2 Semi-Automatic Monoplotting for GIS Data Capture

Object extraction from images for GIS data capture includes three operations:

- ❑ *identification* of an object within an image, which involves image interpretation, understanding and object classification,
- ❑ *tracking* the object by precisely determining its outline, and
- ❑ *linking* the obtained information to a reference datum.

It is well known that there exist no *universal* edge detectors which could be applied to a digital image function to both identify and track object outlines with sufficient success. Instead, there is a trade-off between qualitative accuracy, associated with identification, and geometric accuracy, associated with tracking. According to these measures, one can classify existing operators into two broad categories [Fischler et al., 1981]:

- *type I operators*, offering high accuracy in properly identifying classes of objects without particularly dealing with precise outline determination, and
- *type II operators*, which do not aim at accurate identification, but instead offer high precision in detecting outlines, provided that adequate approximations of the object location are available.

In an effort to optimize both measures, operators from these two classes can be combined in complex strategies for object extraction [Suetens et al., 1992].

We are currently developing a semi-automatic monoplotting strategy for GIS data capture, where the identification task of a type I operator is performed manually on a single image, while a special automatic digital module performs the tracking task of a type II operator. More specifically, a human operator is used to identify an object from an on-screen display of a digital image, select the particular class this object belongs to (e.g. road, house etc.) and provide a rough approximation of its outline. Typically, this approximation consists of loosely identifying on-screen outline nodes (e.g. corners for houses, breakpoints for curvilinear objects etc.). Subsequently, these points are used as approximations for automatic precise edge positioning. By repeating this process, any object in an image can be identified and precisely positioned. The degree of automation can vary according to the extent of the required human operator contribution (e.g. how many nodes have to be provided for successful object extraction and how close to the actual outline breakpoints they should be). By performing object extraction on digital orthophotos tied with an associated DTM, the obtained information is automatically linked to a reference datum and can be stored in a GIS, together with user-provided relevant qualitative information. Judging from experience in both photogrammetric data capture and digital image object extraction, the use of a human within this GIS-oriented strategy should be considered optimal. Humans perform the identification task flawlessly and almost effortlessly. Thus, their intervention optimizes accuracies without imposing time burden, while the task of precise object outline positioning and tracking, shown by experience to be the most time-consuming and error-prone part of data capture, is performed automatically in a fast and objective manner.

In the next sections, we will present the following novel semi-automatic object extraction modules developed in our Institute:

- road extraction from SPOT imagery,
- least squares template matching, and
- globally enforced least squares template matching.