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ScienceDirect
Advances in Engineering Software 39 (2008) 812–820
ADVANCES IN ENGINEERING SOFTWARE
www.elsevier.com/locate/advengsoft

Merging neural networks and topological models to re-engineer construction drawings

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Available online 22 June 2007

Abstract

In this paper an approach is presented to digitize a drawing, to build up geometric and topologic models, to recognise construction parts and to interpret dimension lines and inscriptions. All recognized parts are transformed into a three-dimensional geometric model which provides all necessary geometric information for a product model. The recognition process of construction parts is based on a line search and topological analysis, which are not suitable for the recognition of drawing inscriptions and hand writings. Because dimension inscriptions deliver significant information about the dimensions of construction parts, a neural Kohonen network is implemented and adapted in order to recognise inscription text. Finally the gained information about dimensions is related to significant details of construction parts.

Keywords: Neural networks; Topological models; Re-engineering of construction drawings; Identification of constructions parts; Correction of identified part dimensions

1. Introduction

Nowadays CAD-systems support 3D-modelling of buildings and are well integrated into the planning process. Furthermore the application of product models for buildings is recommended to manage and use product-related attributes. This facilitates the cooperation of all experts involved in a particular project. Required information can retrieved from the product model and results of the planning process can be saved to the product model. The development of product models and the integration into the design and planning process is a vital aim of the actual research in the area of computing in civil engineering. Product modelling is one of the key issues of the DFG priority program 1103 [1] concerning network based co-operative planning processes in structural engineering. Consequently, the actual research work has been considered in strong correlation to this priority program with a special focus to the re-engineering process of existing buildings. The case study in this contribution concerns an old barrack build in the beginning of the last century and used nowadays as offices of the University of Hannover. A ground floor plan of the first storey of this building is shown in Fig. 1.

In general, the digitising of paper-based drawings in CAD-systems is conducted manually. Important points and lines are selected manually and the related coordinates are saved to the digital drawing model. This is a very time-consuming job, which does not allow any semantic interpretations. Dosch et al. [2] developed a system for graphic analysis and pattern recognition in the area of architecture with a great range of functions. Especially for the constructional engineering this system does not fulfil practical requirements, because drawing objects in construction drawings differ a lot regarding to their form, extent and orientation.

Therefore in this contribution a procedure with line identification is preferred. Different methods such as "orthogonal zig-zag" [3] or "spare pixel tracing" [4] are used for

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0965-9978/$ - see front matter
doi:10.1016/j.advengsoft.2007.05.006

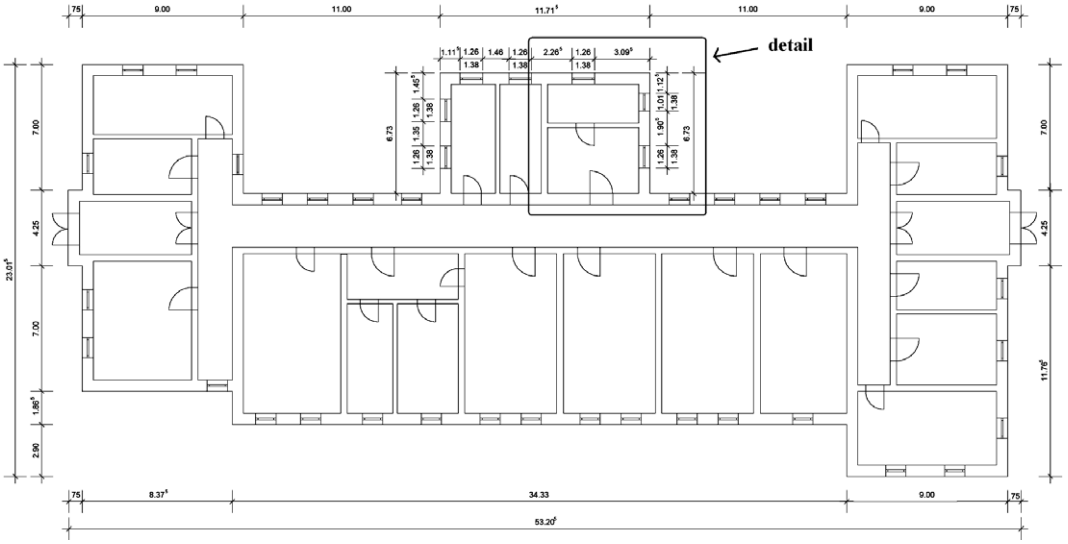

Fig. 1. Scanned ground floor plan of the barrack building.

vectorisation in commercial systems. In this contribution a procedure with a medial axis set up from the burning algorithm by Lindquist and Lee [5] is introduced. This burning algorithm is the basic foundation of different algorithm for line recognition in pixel-based drawings [6].

Unfortunately this approach based on topological information is not sufficient for the recognition of inscriptions. If the dimensions of construction parts are gained exclusively by scaling the scanned lines, remarkable inaccuracies for the dimensions of construction parts can occur and in some cases the topological correctness of the geometric model could not be assured.

To overcome these difficulties of inaccuracies the inscriptions of drawings have to be interpreted, which is realized by merging the information obtained by a neural network and the topological model. Therefore an implementation of a Kohonen network realized by Heaton [7] is adapted to recognize standard lettering as well as handwriting in drawings [8]. The information gained from the Kohonen network and the topological model is merged in order to identify single characters, to combine single characters to inscriptions and finally to relate the inscriptions to dimension lines and construction parts. The gained inscription information is essential for the check-up and correction of the construction part dimensions identified by the topological line search process. Finally all recognised parts are transformed into a three-dimensional geometric model which provides all necessary geometric information for a product model.

In this contribution the theoretical basis and practical applications of merging neural networks and topological models and of the re-engineering process are presented. All algorithms and methods are implemented with the Java programming language. A case study of an existing building (Fig. 1) demonstrates the usability and efficiency on the outlined approach.

The identified inscriptions, dimension lines and in particularly the corresponding relationship to construction

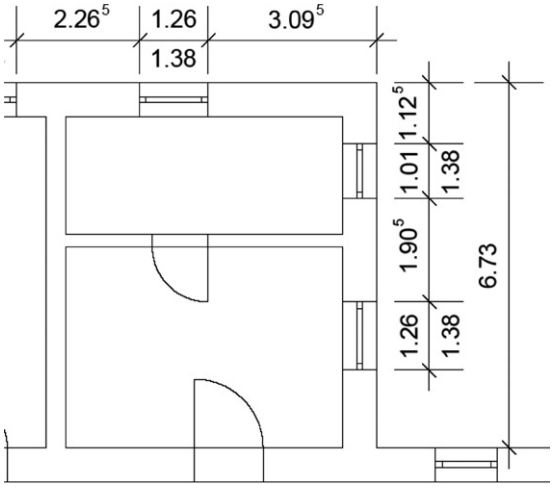

Fig. 2. Detail of the ground floor plan.

parts are illustrated in detail. For a demonstrative explanation a detail (Fig. 2) of the ground floor plan is used. Finally, the whole floor is shown in Fig. 22 as the result of the identification process after the integration into the IFC-product-model [9].

2. Identification of lines in pixel-based drawings

First of all, in the re-engineering process the construction drawing is scanned and converted to a pixel-based picture. All pixels in the drawing have different grey scale values. A line in the pixel grid is then defined by a straight-lined connection between two pixels. All pixels which are touched by this line are assigned to this line. For the identification of lines in pixel-based drawings the grey scale range of all pixels is separated into background and line pixels. The limit grey scale value separating line pixels and background pixels has to be defined by the user.