

Enhanced DEM-based flow path delineation methods for urban flood modelling

J. P. Leitão, D. Prodanović, S. Boonya-aroonnet and Č. Maksimović

ABSTRACT

In order to simulate surface runoff and flooding, one-dimensional (1D) overland flow networks can be automatically delineated using digital elevation models (DEM). The resulting network comprises flow paths and terrain depressions/ponds and is essential to reliably model pluvial (surface) flooding events in urban areas by so-called 1D/1D models. Conventional automatic DEM-based flow path delineation methods have problems in producing realistic overland flow paths when detailed high-resolution DEMs of urban areas are used. The aim of this paper is to present the results of research and development of three enhanced DEM-based overland flow path delineation methods; these methods are triggered when the conventional flow path delineation process stops due to a flow obstacle. Two of the methods, the 'bouncing ball and buildings' and 'bouncing ball and A*' methods, are based on the conventional 'bouncing ball' concept; the third proposed method, the 'sliding ball' method, is based on the physical water accumulation concept. These enhanced methods were tested and their results were compared with results obtained using two conventional flow path delineation methods using a semi-synthetic test DEM. The results showed significant improvements in terms of the reliability of the delineated overland flow paths when using these enhanced methods.

Key words | digital elevation models, dual-drainage modelling, overland flow path delineation, pluvial flooding, urban water

INTRODUCTION

Flood events caused by intense rainfall, which are becoming considerably more frequent, can cause significant damage, especially in urban areas. According to Pitt (2008), over 60% of flooding damage in urban areas in the UK in 2007 flood events was caused by this type of flood. Enhanced urban drainage models are therefore needed to simulate correctly the hydraulic behaviour of the drainage systems and accurately predict flood location, magnitude and duration. These models are important tools for city planners, drainage utility managers, emergency managers and other decision makers.

Until recently, conventional urban drainage models only considered the flow in the sewer system, neglecting the impacts of the overland flow system and the links between these two systems in cases of urban flooding. However, to accurately model the drainage system during flooding

events it is necessary to include both the sewer and the overland flow systems, in other words, to implement the dual-drainage concept, as described by Djordjević *et al.* (1999). This concept relies on the simultaneous simulation of both sewer and overland flow systems that are connected through the computational nodes (manholes). Kinouchi *et al.* (1995) and Mark *et al.* (2004) investigated the numerical problems associated with the simultaneous modelling of the two linked systems using a simple concept, in which the overland flow route is parallel to the (underground) sewer system. In these two studies, the overland flow system corresponded to the roads of the catchment. Some commercial software packages, e.g. Infoworks CS (Innovyze 2011), have tools to automatically generate overland flow paths based on digital elevation models (DEM). However, these tools are not capable of generating full overland flow systems, as

J. P. Leitão (corresponding author)
Laboratório Nacional de Engenharia Civil (LNEC),
Av. Brasil, 101, 1700-066 LISBOA,
Portugal
E-mail: jpleitao@lnec.pt

D. Prodanović
Faculty of Civil Engineering,
University of Belgrade,
Bulevar Kralja Aleksandra 73,
11000 Belgrade,
Serbia

S. Boonya-aroonnet
Environment and Resources Engineering,
Hydro and Agro Informatics Institute (HAI),
Bangkok Thai Tower,
Ratchatewi, Bangkok 10400,
Thailand

Č. Maksimović
Department of Civil and Environmental
Engineering,
Imperial College London,
South Kensington Campus,
London SW7 2AZ,
UK