바이모달 트램의 안전 운행을 위한 웹기반 재해관리 시스템 Prototype 버전 개발

Development of Prototype Web-based Disaster Management System for Safe Operation of Next Generation Bi-Modal Tram

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국문요약

최근 들어 한국철도기술연구원 (KRRI) 에서는 자동운행이 가능한 바이모달 트램 시스템을 개발하고 있다. 이 바이모달 트램 시스템은 노선에 설치된 센서를 자동으로 인식하여 자동 운행을 하며, 재해 발생시 수동으로 운행될 수도 있다. 바이모달 트램 시스템이 노선에 설치된 센서를 인식하여 자동운행을 하기 때문에, 기후패턴 변화에 따른 집중강우로 인해 예기치 않은 홍수 발생시 바이모달 트램 시스템 승객 및 차량의 안전이 확보되어야 한다. 따라서 본 연구에서는 Web GIS 기반의 트램 재해관리 시스템 (Bi-modal Tram Disaster Management System: BTDMS) 프로토타입 버전을 개발하였다. 이 BTDMS 시스템은 US EPA에서 개발한 SWMM 모형을 핵심 엔진으로 활용하여 지표면 유출 및 관거 해석을 수행한다. 본 연구에서는 기상청 예측 강우량 자료를 이용하여 실시간 내수침수 예측을 수행할 수 있는 모듈, 지표면 유출수의 흐름을 고려할 수 있는 모듈, 그리고 지역별로 유출심을 산정하여 바이모달 트램 시스템 운행 판단의 기준자료로 활용할 수 있는 모듈을 개발하여 BTDMS 에 추가하였다. 이러한 모듈을 이용하여 예측된 자료는 바이모달 트램 시스템의 운행 속도를 늦추거나 우회노선을 선택하는데 활용될 수 있을 것이다. 본 연구에서 개발한 Web GIS 기반의 BTDMS는 2009년 상반기 밀양 지역에 설치될 바이모달 트램 시범지역에 적용되어 그 적용성이 평가될 것이다.

1. Introduction

Many attempts have been made to overcome limitations in existing transportation in many countries (Federal Transit Administration, [1]). It was found that the Bus Rapid Transit (BRT) system has advantages over others in providing flexibility as well as fastness with low cost. The BRT system has been operating in USA as well as many other countries because of its lower construction cost compared with other transportation, transportation speed increases with introduction of bus-only lane, on-time schedule, and other miscellaneous bus service facilities. Compared with the BRT system, the Bi-modal Tram system which is now being developed in Korea is upgraded transportation system. The Bi-modal Tram system provides mass-transportation service with environment-friendly, human-centered transportation system. Thus, safety needs to be secured in operating Bi-modal Tram system. In Korea, increasing urban sprawl and climate changes have been causing unexpected high-intensity rainfall events. Urban flooding with surcharges in sewer system has been investigated

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because of unexpected torrential storm events these days, causing significant amounts of human and economic damages. So, there are needs to enhance conventional disaster management system for comprehensive actions to secure safety.

Thus, the object of this study is to develop the prototype version of the Web GIS-based Bi-modal tram disaster management system (BTDMS) using the SWMM model (Urban Watershed Management Research, [2]) to secure on-time operation and safety of the Bi-modal tram system. Although there are limitations in forecasting and preventing natural disasters, integrated urban flooding management system using the SWMM engine and Web technology will be an effective tool in securing safety in operating Bi-modal transportation system. In addition, the integrated urban flooding management system can be linked with general and transportation-related disaster management system in the future.

2. Methodlogy

2.1 Study Watershed

In this study, the study area, located in Chuncheon, Gangwon province, was selected to evaluate the applicability of Web GIS-based BTDMS in forecasting urban flooding due to surcharges in sewer system. The catchment is 21.10 ha in size and the average slope is 2% in lower flat areas. Most of the study area is impervious area and 2-4 story residential building is located. The digital map of 1:1,000 scales was used to extract topographic information in study area to define subcatchment boundaries. The sewer system inventories at the study area was obtained from the Chuncheon city and were used in SWMM model input parameters. The subcatchments, conjunctions, and conduits information were integrated in the SWMM interface to model the reality. To predict flooding areas, the field surveying was conducted for more details in lower part of the study area.

2.2 Development of design rainfall estimation module using Huff method

To simulate the urban flooding using the SWMM model (Huber and Dickinson [3]), very detailed rainfall distribution data first need to be defined in the SWMM. Thus, the design storm distribution was created using the probability distribution of rainfall events for various recurrence intervals and storm duration. To facilitate these processes, the nation-wide probability distribution of rainfall event Web database was created and the interface between the Web database and the SWMM interface was created in this study. The probability distribution of rainfall events data is stored in the MS SQL DB at the server-side and the simple interface retrieves the data from the database and then generates design storm data for the BTDMS. With nation-wide database, the BTDMS can be easily used at any locations in Korea with no additional programming. This module can be used in real-time forecasting of urban flooding in operating the Bi-Modal tram system with the Korea Meteorological Administration (KMA) forecasting rainfall amounts on the KMA web site.

2.3 Development of Overland Flow Module for Spatial-Temporal Visualization Module

The current SWMM module does not allow overland flow for multiple subcatchments. Thus the new module was developed to enable the simulation of overland flow at multiple subcatchments from upper subcatchment for practical simulation of the overland flow in case of flash flooding. In this study, very detailed subcatchment networks were defined and the flow allocation database was prepared for the study watershed as shown in Figure 1. In this module, the surface storage of each subcatchment can be defined in the flow allocation database. With these data, new module can simulates realistic overland flow to secure the safety of the Bi-modal tram system. To provide visual simulation results for BTDMS, the SWMM interface

was modified and runoff depth module was developed. Figure 2 shows the runoff depth visualization interface, developed with modifications in SWMM engine and the interface. The runoff volume was converted into runoff depth by considering the area of each subcatchment.

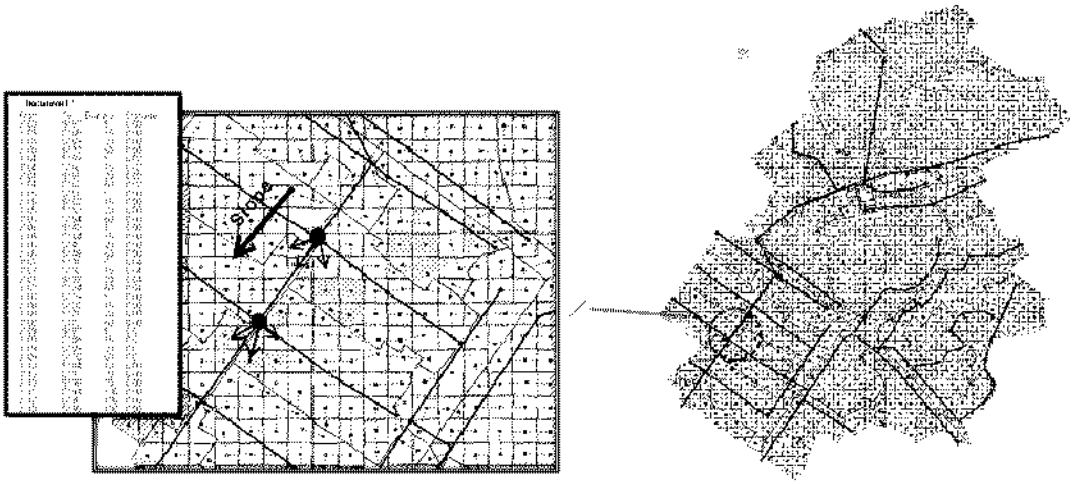


Figure 1. Development ofOverland Flow Simulation withSurcharged Flooding Data

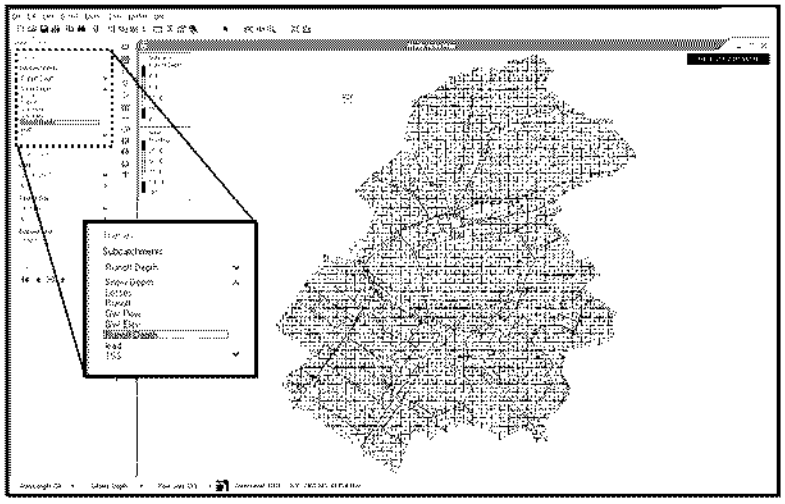
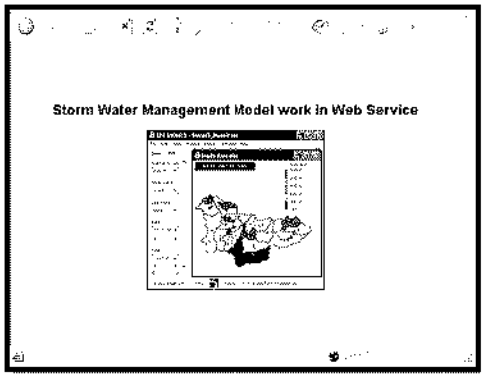


Figure 2. Specification of 'Runoff Depth' by SWMM engine analysis

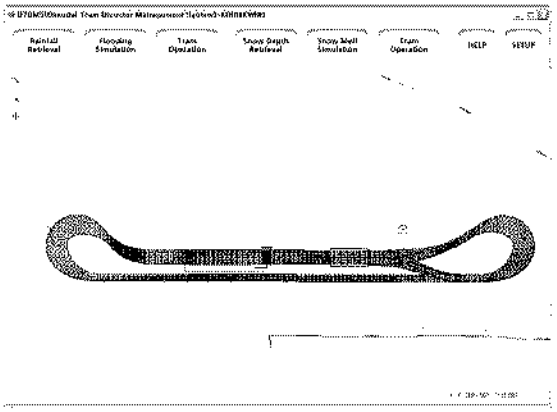
3. Development of Prototype Version of Web GIS-based BTDMS

For fast and accurate simulation of urban flash flooding to secure safety of passengers and the Bi-modal tram, the prototype version of Web GIS-based BTDMS was developed in this study. Most of SWMM functionalities are not needed for the Web GIS-based BTDMS, thus SWMM interface was modified for realistic simulation of the urban flash flooding. In this study, BTDMS loading module was developed with the Active X programming to install the BTDMS and perform general check-up for stable operation of the system. With this, user authentication will be performed for safety reasons and regular checkup for the newer version will be handled. Figure 3 shows the prototype interface of the Web GIS-based BTDMS, developed

with Active-X programming and modifications in SWMM engine and interface. Currently work is underway to finalize system interface, to be compatible with the Bi-modal tram operating system.



(a) Loading Module for BTDMS



(b) Prototype version of the BTDMS

Figure 3. Web GIS-based Bi-modal Tram Disaster Management System

4. Conclusion

In this study, the prototype version of the Web GIS-based Bi-modal trams disaster management system (BTDMS) was developed with newly developed modules to simulate urban flash flooding using the SWMM as a core engine. For accurate simulate urban flash flooding, design storm module, overland flow module, and visualization module was developed with modifications in SWMM engine and SWMM interface. With nation-wide design storm module using the Korea Meteorological Administration (KMA) and Huff module, the Web-based BTDMS can be applied to any location in Korea. Because of limitations in current SWMM in simulating the overland flow due to surcharges in sewer system in very complex topography, the overland flow module was developedto simulate overland flow from upper subcatchment to multiple downward subcatchments. Although these flow allocation data needs to be prepared based on the flow paths and topography of the study area, these provides flexibilities in simulating overland flow due to buildings and other structures in the study area affecting overland flow. The flash flooding visualization module was developed for sate operation of the Bi-modal tram in this study. With this visual interface, the Bi-modal tram operation can be rescheduled or re-directed to other safe routes in real-time. The BTDMS surface flow path module was developed for practical simulation of urban flash flooding. The prototype version of the Web GIS-based BTDMS will be applied to test-bed route to validate its performance soon. With the GIS-based interface in the BTDMS system, this BTDMS system can be easily applied to other Bi-modal tram route and utilized for other transport facilities.

Acknowledgments

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