Watertown – a computer game for city water planners

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Abstract

This paper outlines a novel approach to communicating flooding and water quality problems in cities using computer game technology. WaterTown is an accessible and visually attractive computer tool intended to communicate water management issues to a varied audience. The game has three main strands; flooding caused by a range of problems such as increased precipitation due to climate change, construction of towns and cities, pollution of lakes and rivers, and, damage to historic buildings due to soil drying out.

WaterTown has been developed to help city planners understand the issues caused by progressive development and redevelopment of urban areas which result in diverse problems such as low river banks and bridges and sewers which overflow causing pollution. The development of WaterTown has been driven by recent changes in legislation and policy at a European level, particularly the recent EU Floods Directive. At a regional level, changes in ownership and management responsibilities of sustainable drainage within different regions of the UK have been a strong driver for improved engagement with water issues in cities. WaterTown is a product of the EU Interreg IVb programme North Sea Skills Integration and New Technologies (SKINT), one aim of which is to widen public consultation and dissemination of water issues in cities.

Key Words

Urban Planning, Computer Game, Flood, Sustainable Drainage, SUDS.

Introduction

Many cities throughout the world have been built close to rivers, lakes or the sea. Whilst this has given the cities good trade links and access to food and water supplies, there can be severe disadvantages such as flooding due to high flows in rivers or heavy rain on roofs and streets, and contamination of the very lake or river which sustains the city. In other locations there may well be pollution from streets and industrial areas washed into streams during heavy rainfall, discharges from combined sewer overflows and diffuse pollution. Further, some archaeological remains are in soft organic sediments and changes in the drainage of a city may dry out ancient wooden buildings causing irreparable damage. While these current issues cause problems now, it is projected that, in future, climate change will lead to heavier rain and more flooding as cities go on expanding.

Strategic planning for integrated urban water management is now one of the primary concerns for new development as highlighted by recent EU Interreg research projects including 'Sustainable Water Improves Tomorrow's Cities Health' (SWITCH) and 'FloodResilienCity' (FRC). City development and planning for future development is a complex process encompassing a diverse range of concerns and water management represents one small part of this. It is not realistic to assume that city planners are able to develop detailed knowledge of every development constraint.

Whilst there are many sources of knowledge to assist with city planning, few are interactive and, although computer software packages are available which provide simulation and analysis of hydraulic design within catchments, these packages are intended to be used by qualified engineering professionals and are generally unsuitable for other decision makers in the planning process. Furthermore they do not provide the user with a clear indication of the range of problems that localised flooding and pollution events can incur.

The University of Abertay Dundee is working within the EU Interreg IVb programme North Sea Skills Integration and New Technologies (SKINT), and is responsible for the dissemination and delivery of water management best practices in the North Sea Region. A range of training courses have been developed including online modular training, face to face workshops and the development of an interactive computer based game - WaterTown.

This innovative computer game enables new ways of communicating the issues and fresh material for training key individuals. WaterTown is an accessible and visually attractive means to disseminate water management issues to a varied audience and is complementary to the other SKINT project training outputs.

The Context of Urban Water Planning

There are serious concerns worldwide over the capacity of cities to adapt to current flooding problems and to the potential additional impacts of climate change (Blanksby et. al. 2011, Jensen et. al. 2011). In Europe, from a regulatory perspective, the Floods Directive (EU 2007) and the Water Framework Directive (EU 2000) require actions which are both technical and community based since engineering solutions alone cannot resolve all issues without local and national government actions to implement and operate changes (e.g. Rocquelain et. al. 2011). In England, severe floods in 2007 resulted in a major change in policy after a thorough review of flooding and planning (Pitt 2008) and similar reviews of strategy have been undertaken in many countries. Many countries and regions have also developed guidance in sustainable drainage to enable the integration of control of water in with other requirements of open space (e.g. Woods-Ballard et. al. 2007).

Most of the current tools for interpreting the results of technical investigations can only be used by professionals in the field or by lay-people who have had training. This even applies to the most common means of presenting spatial data which is to use Geographical Information Systems (GIS) platforms which, although having the ability to incorporate a great deal of information, are not readily understood by the untrained eye. Further, there is little common language between the urban planner, who has to deal with general concepts, and the hydraulic modeller who addresses every detail as far as the resources available for a model are available. This means that many important decisions are made on the basis of imperfect information which can easily be wrongly interpreted.

WaterTown has been developed to help all those involved with urban planning to interact and find a common means of examining the issues. The gamer must make decisions about planning water in urban areas in a non-technical way while at the same time implicitly addressing technical considerations. It is targeted at senior school students, but should also appeal to local politicians and be ‘fun’ for the relevant professional.

Aims

The aim of WaterTown is to engage with decision makers and provide understandable examples of urban water management issues. Some of these examples are common, others are less frequently encountered.

Providing an interactive means of developing knowledge of real life water management issues will assist with capacity building within key organisations. The main target group is composed of decision makers who are not experienced water professionals and includes politicians, local government staff and their advisers.

The game is offered for use in different European countries and the player can play the game in English, Dutch, German or Norwegian.

Development of the game

The idea for developing the game was the product of two areas of expertise at the University of Abertay which has specialist centres in computer games development and urban water management. The development team is a 'meeting of minds' between water specialists from the University's Urban Water Technology Centre and computer game programmers, artists and developers.

Critical to the successful development of realistic game scenarios has been technical input and advice from partner organisations in the Netherlands, Norway and England.

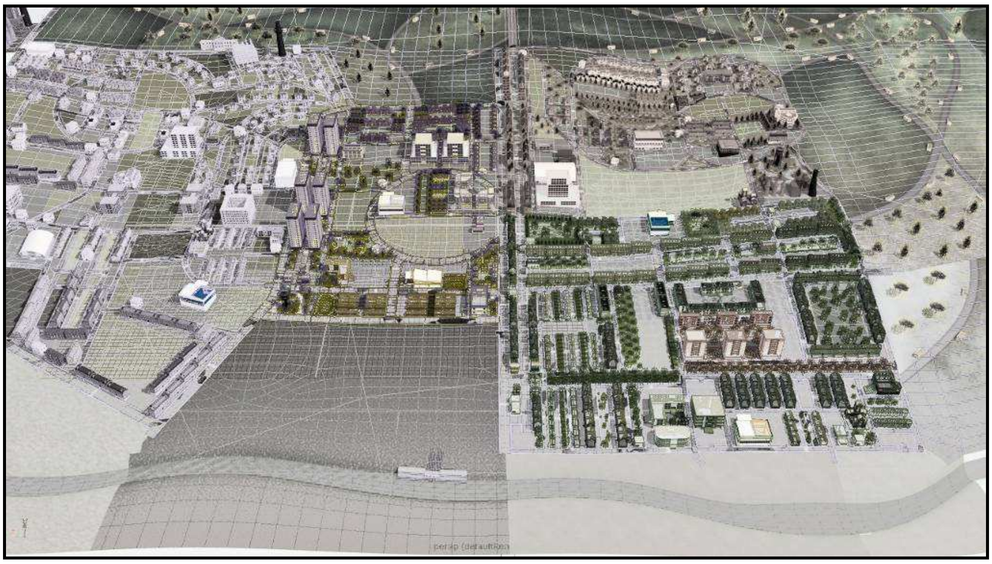

Figure 1. WaterBurgh - a district of WaterTown

Building the basic town

WaterTown has been developed using Maya software, a 3D package developed by Autodesk (Autodesk 2007, Derakhshani 2010). Maya is the basic tool for creating life-like special effects and complex 3D animations and is commonly used within the movie and animation industries (Figure 1 and 2). Similar outputs can be developed in most 3D packages but Maya has specific supporting tools which model the physics of water movement to produce very realistic representations of running water in city environments.

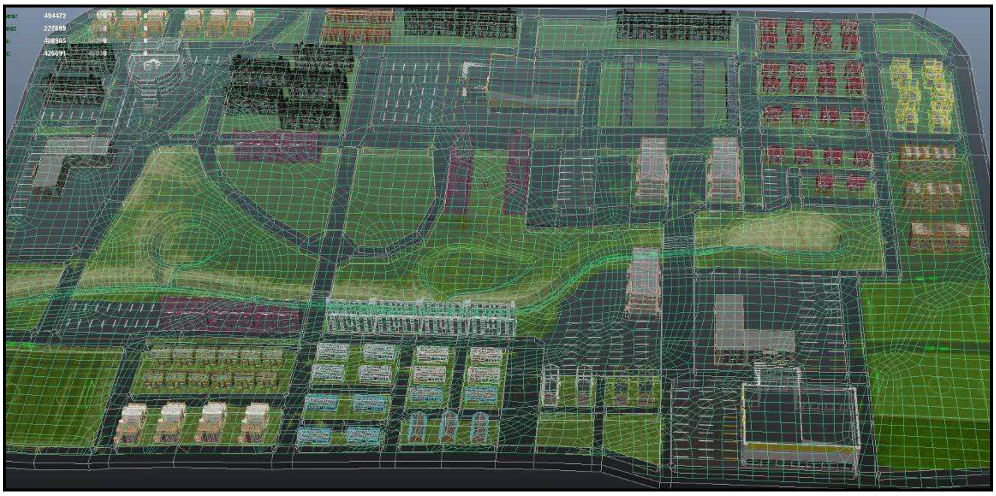

Figure 2. The grid framework underlying part of WaterTown

Maya enables complex 3D game environments to be created. The process is based on layers which permit specific details within the environment to be developed and provides a high level of flexibility to augment the 3D model. Each part of the game has been built from the ground up, creating first the terrain and then adding subsequent layers with details such as roads, buildings, trees and streams. The process finishes with decorative details including lighting columns, post boxes and street furniture.

WaterTown has four sub-areas or districts, each of which has been developed using information supplied by the SKINT partner organisations so that the water problems encountered in Norway, England and The Netherlands can be believably represented. This included the use of digital terrain models (DTMs) which were imported into AutoCAD where they were simplified before being imported into Maya and developed into four separate game districts.

Detailed and recognisable game environments are established by adding game objects within the 3D model (HONGKIAT 2011). The development of these game objects by the 3D artists has been one of the most innovative aspects of WaterTown. Each object is first created as a 3D contour shape consisting of vertices, edges and faces and can either be simple shapes such as cubes, or highly complex shapes involving many polygons.

Adding the complexity of detail required

The second stage of the 3D model development involves UV mapping which links the 3Dmodel and the texture images so that textures can be linked to the object. This process allows textural coordinates (UV coordinates) to be set up on the exterior of an object. Once this is done the next stage is to attach textures to the UV coordinates. Textures are combination of different aspects including image, colour palette or gradient, and the texture dictates how light and shadow, appear on the object. They also enable, for example, the external finish of a building to be altered very quickly so that it might appear to change from being a typical building in Holland to one in England.

Detailed objects within the game include small and large buildings, infrastructure such as roads, railways and rivers, and amenity features such as play area etc. There is also a range of less complex low polygon items with high resolution textures, providing photo-realism to the landscape. Examples include trees, street signs, cars, bins, and post boxes. Typical objects are illustrated in Figure 3.

Figure 3. Game object development and exterior texturing

Buildings are a key part of the layouts of the districts and different types and styles have been developed including houses, schools, churches, commercial and industrial units. The use of alternative textures, particularly for buildings, allows the different districts of the game to represent a particular country giving the appearance of specific locales.

The current trend within the games industry is to develop highly realistic games, often movie like in nature. The game areas and objects within WaterTown have been built to a high level of detail but the 'realism' has been intentionally reduced so that they appear as animated objects. This approach has been taken so that it is clear to the player that they are in the game environment and that the emphasis is slanted towards learning rather than playing an action game.

Adding Water to WaterTown

Creating realistic water and flow regimes within the game was critical to producing the believable flooding and water quality scenarios which form the backbone of the game. Water is created by emitting a large number of small particles from a point which might be in a stream or from a sewer. The particles are effectively small balls, each of which has a vortex and gravity applied (Palmer 2009). Once emitted at the selected location, the balls roll down the slope to its lowest point or until they meet a barrier as shown in Figure 4. By adjusting the physics of each particle and the number emitted at each location, and by assigning gravity and vortex templates the flows of water are applied to the different scenarios within the game.

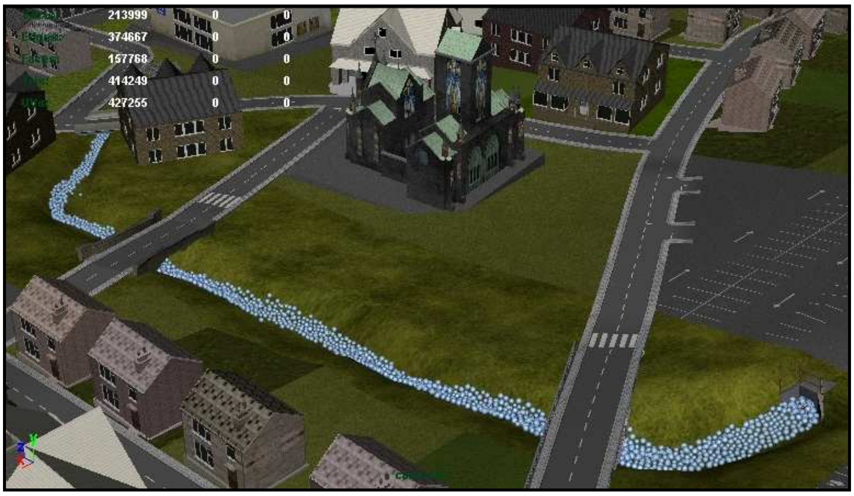

Figure 4. Development shot of water flow through an open section of watercourse

The different topography of the four districts was developed to resemble real catchments so that when the particle package is applied, the flows of water resemble those of the natural environment. Degrees of realism for storm events are catered for by varying the number of particles introduced (per second) to the topographic model, thus replicating different flood flows and storm durations. Shaders are used to vary the colour of the water to aid realism - for example brown water to resemble construction run-off.

Maya renders a sequence of images to produce video. For example if 20 seconds of video (at 25 frames per second) is required then a total of 500 frames (images) must be created. The post production process is carried out using After Effect software which combines the images together to create video sequences, and allows correction of the colour palette.

Decision trees are at the centre of the game make-up and are used to determine the range and extent of the learning scenarios. Each scenario is first prepared as a storyboard by the water specialists and then videos created by the 3D artists. The output is a series of short video clips as shown in Figure 5.

Figure 5. Flood flow static images from two options in one Wetley-Tetley scenario

Districts and Scenarios

Districts

WaterTown has four districts which are effectively four sub-games where different scenarios needing capital and resources are played. Each district includes multiple scenarios in which the player is challenged by different options, all of which involve delivering a better plan for water in cities. The game districts reflect current issues which require to be resolved in the countries of SKINT partner organisations.

Scenarios

The scenarios represent detailed situations based on real life problems. Each scenario challenges the 'gamer' to decide upon a possible solution, balancing an environmental issue with available 'game credit'. The 'game credit' has a different meaning depending on the district of the game being played. It might be money for the construction and operation of new flood protection works, political popularity for the Member of Parliament who makes most people happy or alternatively it could represent a historical legacy which might be lost.

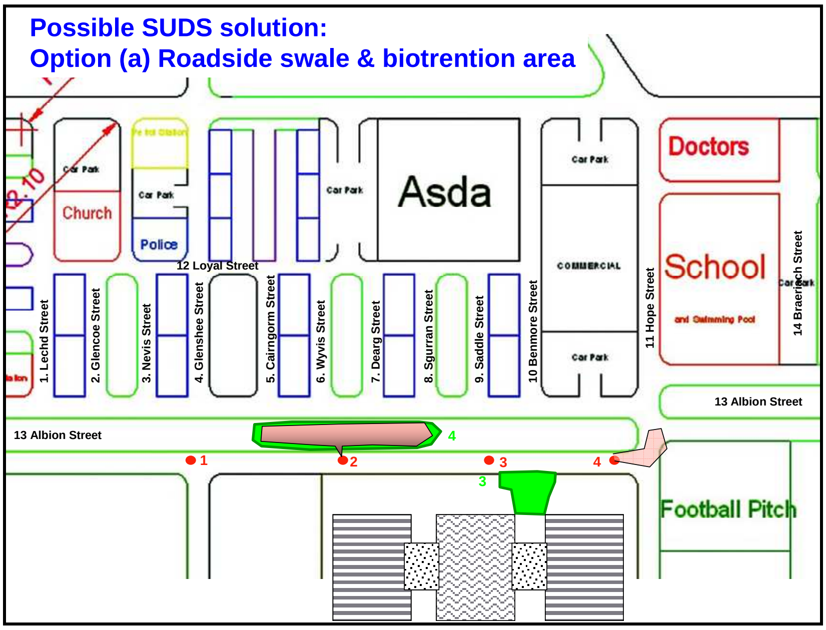

Figure 6. Initial storyboarding of scenarios in Waterburgh prior to 3D development in Maya

Waterburgh represents water management issues typical of towns and cities in Scotland where the installation of sustainable urban drainages systems (SUDS) is mandatory in all new developments. In Waterburgh, the gamer must decide the best way of incorporating SUDS into the built environment (Figure 6). The scenarios in Waterburgh demonstrate the suitability of SUDS in specific locations and the design, operation, maintenance and safety issues which must be resolved for their implementation.

Wetley Tetley introduces the small scale but serious challenges encountered in steep urban stream catchments where the existing drainage infrastructure is completely inadequate. The scenarios have been developed in conjunction with Bradford Metropolitan District Council and are based upon documented flood problems in the town of Ilkely in Yorkshire. Scenarios include culvert design, operation and maintenance, stream flooding and require the 'gamer' to reach a compromise between flood damage and the costs of mitigation.

The Bloody Nose Game has been developed in collaboration with the Dutch Water Company Hoogheemraadschap Hollands Noorderkwartier (HHNK). This game provides examples of water management within the small coastal resort of Egmond an Zee in the Netherlands. It focuses on the detailed design of sustainable drainage including swales (wadis), permeable paving, infiltration zones and speed bumps. Egmond is a typical densely developed small town which floods during heavy rainfall. Local political issues strongly influence the development of solutions in such situations since there may be significant disruption before and during construction and tempers break. The bloody nose game challenges the 'gamer' to produce a technical solution which causes the local politician least unhappiness.

The 80 Million Kroner Settlement is based on the ancient buildings of Bryggen in the city of Bergen, Norway and is being developed in collaboration with the Geological Survey of Norway. The buildings in Bryggen are of such historic value that they have been declared a UNESCO World Heritage Site down to as far as 8m below ground. The ancient wooden wharves and foundations of the buildings are settling and disappearing because the organic soil layers are drying out. This problem occurs in many historic locations in Norway where they are known as underground cultural deposits. This district of WaterTown provides game scenarios relating to the impact of urban development and the interaction of surface water and groundwater on these cultural deposits. The successful 'gamer' conserves the maximum amount of the cultural heritage.

Playing WaterTown

Game play for most of the learning scenarios is by 'click and play' video game; where the player is presented with a finite range of options which are shown in concept in Figure 7, and once a decision is made, the resulting outcomes are shown as a sequence of seamless short videos. This structure provides an interactive approach to knowledge development and allows the impact of decision making to be clearly understood.

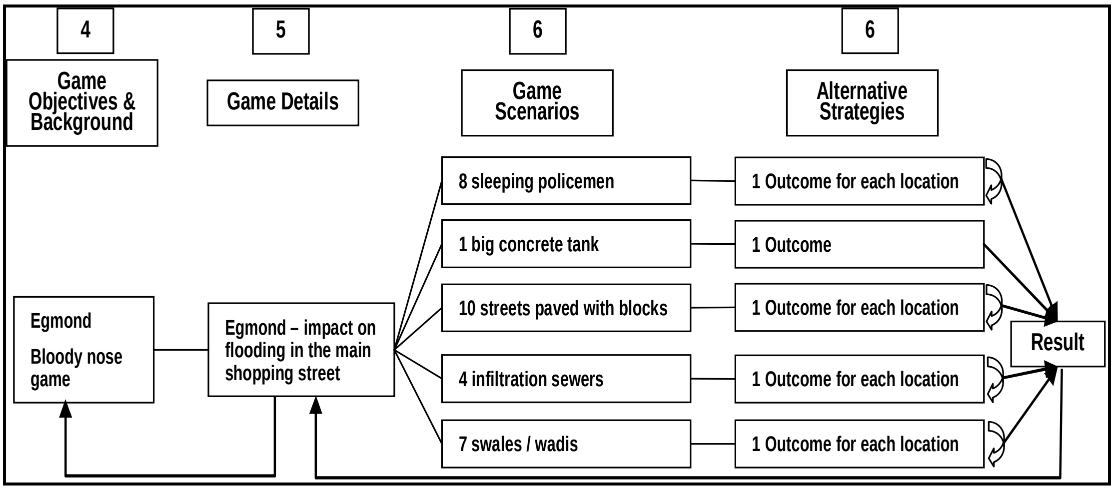

Figure 7. Section of simple decision tree for the Egmond game district

Play begins with the player accessing the game by the home screen where the game language is selected and information about the game may be viewed.

The main game screen provides information on how the game works, explaining that it is a points-based game where the player receives credits for successfully completing game scenarios. Each of the four main game areas are shown on the main game screen along with an explanation of what each scenario entails, allowing the player to choose which game they wish play first.

Each of the four game areas and supporting scenarios include links to other information sources which include engineering drawings, information sheets, images and videos. The player is presented with a series of choices to solve the problem, and short videos show the outcome of their decision. Depending upon the level of success, points are assigned and a cumulative game score is given as the player continues to the subsequent game areas and scenarios.

Discussion

Testing of the game whilst under development is critical to ensure that it provides comprehensive learning scenarios which lend to knowledge development of professionals involved with urban planning. Testing is being carried out by a range of professionals; both water specialists and other non-water development specialists. A second stage of testing is also being carried out in tandem; with secondary school children. This testing will provide a base level to help assess feedback received from the water and non-water professionals.

A pre-release version of WaterTown was exhibited at the 2011 SUDSnet Conference in Dundee. It attracted much interest from Transport Scotland staff, practitioners and other water and non-water professionals. One key theme emerged from the feedback; that the games key potential is bridging the gap between different professions and lay people.

The game areas are not models of specific locations but are intended to provide familiar locations and water management issues; these are be used to 'train' decision makers of the future in how to interpret the planning problems which arise from a surplus of water in urban rivers and streams.

The four different districts cover most of the potential scenarios encountered in real life decision making, including the integration of ecosystem services into the urban infrastructure, providing a comprehensive basis for knowledge development of today's and tomorrows decision makers.

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