A SURVEY OF COMPUTER SOFTWARE FOR THE SIMULATION OF CITY CENTRE SQUARES

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Abstract: Within the current urban design process there are increasing examples of three dimensional computer representations which allow the user to experience a visual sense of the geometry of city squares in an urban landscape. Advances in computer-aided design have contributed to this visual assessment, but there have only been limited attempts at 3D computer representations which allow the designer to simulate urban quality aspects relating to square design. This paper proposes that the incorporation of appropriate software applications into the urban design process can enable urban designers to more effectively test and develop their designs with consideration of user comfort. The incorporation of findings and results from these software applications into Virtual Reality (VR) technologies will also allow users to gain a *greater sense* of the urban space and to communicate the design and its effect on urban quality aspects more effectively. This paper presents the results of a study to select computer tools that could contribute to a more holistic approach to urban design. It will demonstrate a methodology for the selection and filtering of appropriate computer applications that could support the simulation of three-dimensional geometry, urban texture and urban quality aspects relating to the design of city centre spaces, before offering an evaluation of these tools.

Keywords: Urban design, software selection, software evaluation, virtual simulations, 3D modelling

1. INTRODUCTION

The main objective of the urban designer is to formulate and present the design as accurately and vividly as possible (Gosling and Maitland 1984). It is therefore a visual assessment of space that is necessary in the design process. Within the traditional methods of visualisation, current design methods only allow for a 2D representation of a space to be created (Xia and Qing 2004). Although architectural design practices can produce computerised renderings or 3D computer massing models that allow for a more accurate representation of the space, there have only been limited attempts at three dimensional computer representations which allow the user to get a greater sense of the urban space. Ratti and Richens (1999) propose that the further application of three dimensional computer representations would be the ability to analyse and simulate visual and non-visual aspects of urban design; a change in a building's urban fabric and density, the noise environment, microclimate and the ability to control the height, colour and style of the buildings, would all aid urban designers in improving the quality of city centre spaces

This paper will evaluate the use of several commercial and academic software applications for use in the urban design process. The paper will be structured around a systematic review used to identify software capable of modelling the basic elements that make up the urban space; buildings, street furniture, art, floorscape, etc. Software capable of analysing the variables within urban design; pedestrian movement, noise, wind, thermal comfort properties and natural lighting will also be identified. Finally software capable of simulating the elements and variable of urban spaces in real-time will be selected. Therefore the review will concentrate on identifying and selecting software from six established categories; 3D geometric modelling, pedestrian modelling, noise mapping, thermal comfort, wind analysis and platforms (VR engines). The paper depicts this study and presents initial findings and results to date from evaluating three of the selected software application. All of the software will be evaluated on its ability to simulate real-world characteristics of a selected city centre square within Birmingham, UK. The evaluation of the selected software applications will be done by structured criteria based on the requirements of the research. The paper begins by giving a background to design criteria for city centre spaces which underpins this research.

2. BACKGROUND TO RESEARCH

Urban design is primarily and essentially three-dimensional design (Gosling and Maitland 1984), concerned with the shape, the surface and its physical arrangement of urban elements; the basic components that make up the built environment at the level of buildings, spaces and human activities (Xia and Qing 2004). However, both Gosling and Maitland (1984) and Ratti and Richens (1999) identify that urban design is also concerned with the non-visual aspects of environment, such as noise, wind, temperature and humidity which contribute significantly to the character of an area. This view has led them and others to identify the need for a holistic approach to urban design, one not only dealing with the geometrical characteristics of urban design but also environmental issues. This view forms the basis for the research and is the rationale for this study.

Within the last 20 years, several computer tools have been developed to assist in the environmental design of the interior of individual buildings. Heat, light, sound and in particular energy consumption can be analysed in a number of different packages. Ratti and Richens (1999) state that this is not true for city centre spaces. There are computer software applications that can analyse and simulate the visual and non-visual aspects of urban design separately. Some of these software applications are relatively new and some need to be adapted for appropriate use. However there is not one software package that can be used to analyse and simulate all the aspects needed for a holistic approach to urban design. To date there has also been little attempt to synthesise several software applications to aid a holistic approach to the design of city centre spaces; there is clearly a need for an extensive investigation into this area.

In the context of the research background outlined above, the primary aim of the research is to develop virtual simulations demonstrating a holistic approach to the design of city centre squares. The virtual simulation will be developed using a VR engine and incorporating findings and results from other identified computer software applications (Figure 1), resulting in a real-time decision tool for urban designers. The design of city centre squares will be based on key findings from urban design literature and by incorporating appropriate software applications to more effectively test and develop the design with consideration of user comfort.

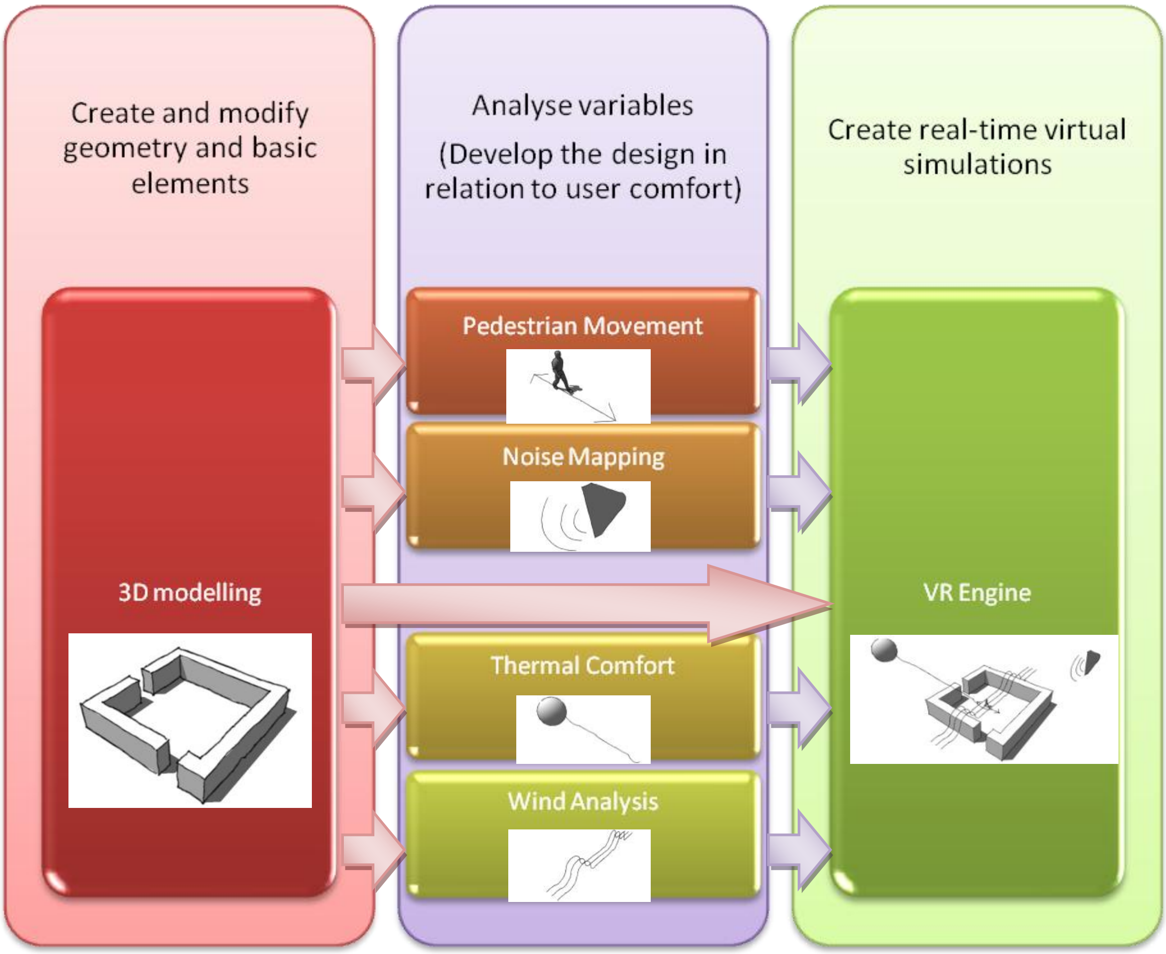

Figure 1. Interconnectivity of selected software applications

3. SOFTWARE IDENTIFICATION AND REQUIREMENTS

As part of the research, urban aspects relating to the design of city centre squares were established from reviewing key theoretical concepts stated in notable urban design literature. To develop virtual simulations, urban aspects established from the review of theoretical concepts of square design will be analysed and simulated using software identified from this survey. The software applications selected for each of the six categories will be used to model, analyse or simulate at least one of the aspects identified to create a holistic approach to urban design, *see; Figure 2*.

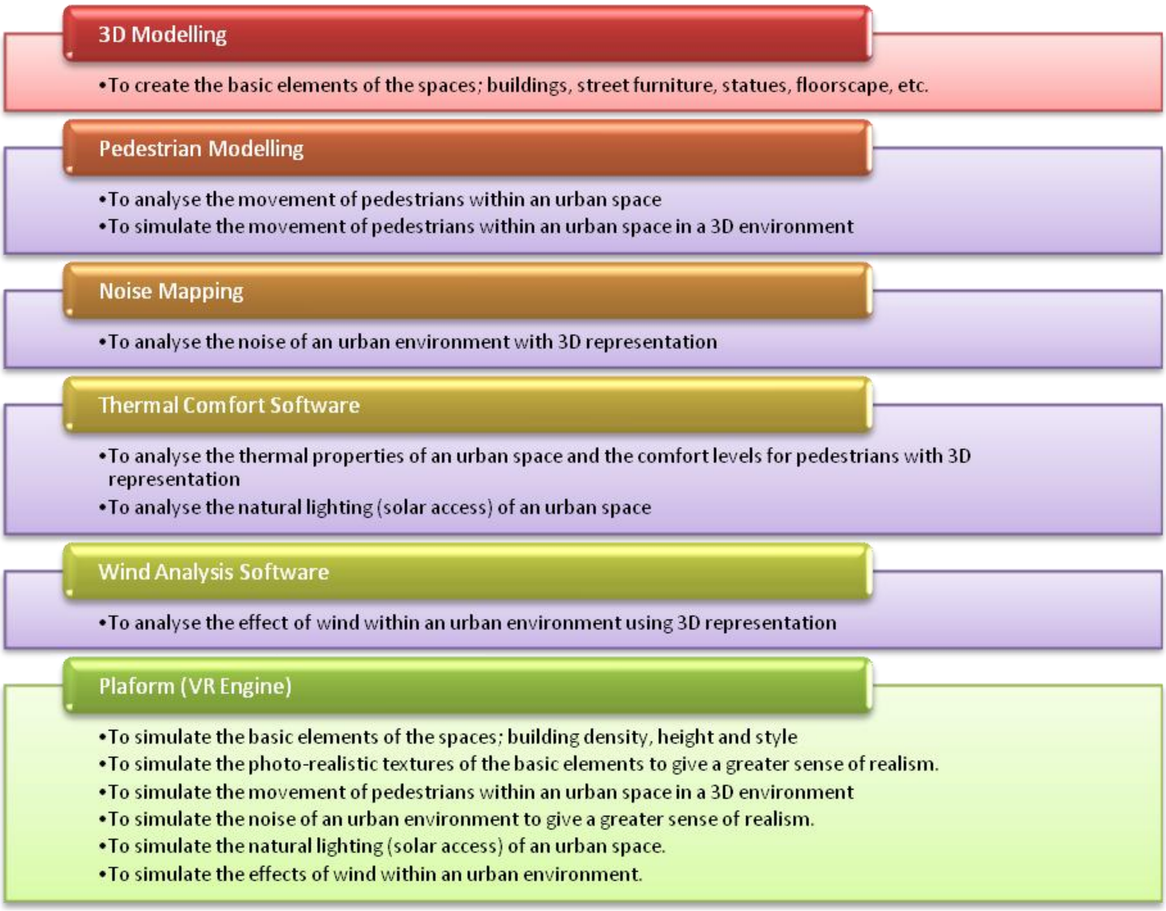

Figure 2. Objectives of each of the software packages.

3.1 Key requirements of software

The premise behind using the selected software applications within the research is to improve the design of city centre squares, in relation to pedestrian comfort. It is proposed that the adoption of these software applications into the urban design process will aid in the effective design of city centre squares. It is therefore crucial that the selected software applications meet a number of set requirements.

A key requirement of the selected software is its capabilities of modelling and visualising geometry and results using three dimensional representations. Another major issue to consider when selecting and validating the identified software is its accessibility and its interconnectivity between other software packages. This would be greatly dependant on the ability of each of the selected software applications for exporting and importing several file formats. The current thinking of the research is that the 3D geometric modelling software would act as the core software, exporting its three-dimensional geometry data to the various software packages for analysis or simulation, *see; Figure 1*. Results would then be exported directly into the VR engine to create and develop the virtual simulation, *see; Figure 1*. Accuracy in both data input and results output is another crucial requirement if the selected software applications are to be effectively used to improve the design of city centre squares. Results produced by the six software applications will be examined for their accuracy by comparing the results to the data and findings established from the fieldwork carried out in the selected city centre square in Birmingham. The accuracy of data input will differ in each of the six software applications and is summarised in Table 1.

Another major issue to consider when selecting and validating the identified software is its ease of use to the user. Selected software should offer a friendly user interface, with little or no need for any programming to take place and where possible the software should offer a quick learning curve in inputting data and carrying out the appropriate analysis.

Table 1. Data input for selected software applications

Software Application	Data Input
3D modelling	Geometry; height, length and width of objects
Noise modelling	Refection and absorption properties of surrounding materials, location and output of noise sources.
Thermal analysis	Longitude and latitude, the North axis, the time of year, weather conditions, air temperature, wind speed and thermal properties of the surrounding materials.
Wind analysis	Wind speed, wind direction, surrounding materials
Pedestrian analysis	Number of pedestrians ay any given time, percentage of types of pedestrians; adult or child, male or female
Virtual reality engine	Longitude and latitude, the North axis, the time of year, weather conditions, wind speed, wind direction, location and output of noise sources, location and output of artificial lighting.

4. SELECTION PROCESS

This study aimed to establish commercial and academic computer software applications, capable of three dimensional computer representations that could be used to analyse and simulate both visual and non-visual aspects of urban design. Upon consultation of academic literature for software identification and selection, the process that was considered most appropriate for use within the research, was the systematic approach adopted by Horne (1998). The process involves; understanding the needs and requirements of the research and identifying a set of criteria to meet these needs, identifying the functional requirements and performance characteristics required by the software, screening potential software and then selecting software.

The methodology adopted uses a selection process to initially identify suitable computer programs. This is then followed by an outlined evaluation of each program by comparing a set of program criteria in the form of a comparison chart. The identification of general attributes of the various potential software packages in this manner enables a filtering process to be used to eliminate clearly unsuitable programs from further consideration. From this filtering process a more detailed evaluation of the program(s) can be carried out. As identified by Horne (1998) this methodology is only adopted for its software selection techniques and no benchmark testing will be used for this study. Benchmarking is usually associated with assessing performance characteristics of computer hardware, for example measuring the processing power, whereas this research is interested in modelling and visualisation capabilities of the software.

4.1 Identification of software capabilities

In identifying potential software for use with urban design, a two stage process was applied to each of the six categories. The first step in identifying potential software was to establish a set of criteria based on the requirements of the software, by which the identified software could be compared against. Although the criteria differed slightly depending on the software in question, it addressed the modelling capabilities, visualisation capabilities, links to other software and evidence of previous use and application within academic research. The second step in identifying potential software was to carry out a technical evaluation of the identified software. The leading features of each of the identified software packages were established and entered into a comparison chart, *see; Table 3*. The features identified for each of the software applications differed depending on the category of software in question. Those features that were consistent throughout are shown in *Table 2*.

Table 2. Features of software applications

Feature	
Origin	**Links to Other Software**
Title	Compatible file import
Author	Compatible file export
Distributor	**Program Availability and Use**
Country of origin	Number of users
Latest Version	Readily accessible
Operating System(s)	Easy to learn
Basic Modelling Capabilities	Requires Training
2D drafting	**Cost**
3D modelling	Cost
Architectural focus	Further Costs
Visualisation Capabilities	
3D visualisation	

Table 3. Example of a comparison chart: Wind Modelling

	Title	Fluent	APUS-CFD	Star CD	MECA Wind	CFX	WinMISKAM
Origin	Author	ANSYS	Symban Power Systems Ltd	CD-adapco	MECA Enterprises	ANSYS	Lohmeyer
	Distributor	ANSYS	Symban Power Systems Ltd	CD-adapco	MECA Enterprises	ANSYS	Lohmeyer
	Country of Origin	USA	UK	USA	USA	USA	Germany
	Launch Date	1988	2005				1989
	Latest Version	Fluent 6.3	APUS-CFD	Star-CD V4	MECA Wind 5	CFX-5	WinMISKAM 5.2
	OS(s)	PC	PC		PC		
Cost	Software cost	£3,950.00			£55.25		£5,844.66
	Further Costs	£1,650.00					£670.64
Basic Modelling Capabilities	2D Drafting	Y					Y
	3D modelling	Y	Y	Y		Y	Y
	Architectural focus	Y	Y	Y	Y		Y
Visulaisation Capabilities	Data Output	Y	Y	Y	Y	Y	Y
	2D output						Y
	3D Output	Y	Y	Y		Y	Y
Links to Software	3Ds / DXF Import	Y	Y	Y		Y	
	3Ds / DXF Export						
Program Accessibilty and Use	Number of users	13,000					
	Readily accessible						
	Easy to Learn		Y		Y		
	Requires Training	Y		Y		Y	Y

4.2 Selection of potential software

Following the identification of the software applications within each of the six categories, the next stage was to carry out the process of selecting the software that would be used within the research. The process of selecting software was done by applying a filtering process to identify software unsuitable for further consideration and those that required further and a more detailed study. The filters used in the survey differed depending on the category in question and the requirements for the software. Generically the filters aimed to identify software that was capable of modelling and visualising in 3D, were developed for or showed evidence of use within the built environment, were capable of linking to other identified software packages and were considered appropriate for use within the research. The filtering process consisted simply of asking closed yes and no questions to identify software that could pass through to the next filtering process. The application of the filters aimed to identify between two to four software applications that were considered suitable for use within the research and required further and a more detailed study. An example of the filtering process is shown in *Table 4*.

Table 4. Example of filtering process: Wind modelling

Software	Filter 1 Capable of 3D Modelling	Filter 2 Architectural Focus	Filter 3 Capable of 3D Visualisation	Filter 4 Can import 3D geometry	Filter 5 Has potential for use	Select
Fluent	YES	YES	YES	YES	YES	YES
APUS-CFD	YES	YES	YES	YES	YES	YES
Star CD	YES	YES	YES	YES	YES	YES
MECA Wind	NO					NO
CFX	YES	NO				NO
WinMISKAM	YES	YES	YES	NO		NO

4.3 Selected Software

The final stage in the survey was to compare the remaining software applications against the initial criteria. This allowed for a more detailed study of the remaining software applications against the requirements of the software. The software applications that were selected for each of the six identified categories and were considered to meet the requirements of the research are summarised below.

3D modelling

3D modelling software packages are difficult to compare because of the many different features that each of the software packages offer. Each one may be targeting its own audience and will therefore accelerate the evolution of features within that area. Therefore, to choose one software over the rest depends highly on the requirements of the user and the intended project. The systematic review of the 3D modelling software established that the software considered appropriate for modelling the 3D geometry was Google SketchUp Pro. Google SketchUp Pro was selected for its ease of use in creating 3D geometrical models, especially low detail massing models necessary for importation into the selected software applications used for analysing the various environmental conditions.

Pedestrian Modelling

There are several pedestrian modelling software packages that are available on the market today. Most of them are very powerful and can successfully simulate pedestrian movement and flow in various environments and situations. However, very few are able to simulate results in a 3D environment, a key requirement of the research. From applying the filtering process to the identified pedestrian software packages, the survey identified that Legion Studio with Legion 3D is considered most appropriate for use within the research. This was due to the advanced features offered by Legion 3D for producing 3D environments and the wide use of Legion Studio within industry for modelling pedestrian movement.

Noise Mapping

The study identified several software applications capable of mapping noise within an urban environment. From the identified software, three certainly appeared more advanced and appropriate for use within the research and urban design. CadnaA, Lima and Predictor are all very powerful noise mapping software applications that have been adopted by many users to map noise within the urban environment. From the application of the systematic review of noise mapping software, the survey identified that CadnaA would be the most appropriate for use within the research. CadnaA was selected as it appeared to have some extra features over Lima and Predictor that would aid in modelling, adapting and editing the created model with greater ease.

Thermal analysis

This survey has only been able to establish two software packages capable of analysing thermal comfort in external urban environments. The software packages identified were; ENVI-met and TownScope. Both software packages are quite capable of analysing and simulating thermal comfort levels, however only TownScope is capable of visualising the results in 3D, a key requirement of the research. For this reason Townscope has be selected for use within the research.

Wind analysis

This survey has identified several software packages capable of analysing and simulating the effect of wind in the urban environment. Software packages built from the start to examine wind, and software packages designed to deal with CFD were identified as possible solutions for the requirement of the research. From the systematic review of wind analysis software, the survey identified that Star-CD would be the most appropriate for use within the research. This was due to its prior use within academic research by I.P Castro, Z Xie et al. at Southampton University, who used Star-CD to research the effects of wind in the urban environment using CFD software in 2006.

VR Engine

The survey has identified several platforms (VR engines) capable of simulating the basic elements of the spaces; building density, height and style. The survey has also identified several platforms (VR engines) capable of simulating; the photo-realistic textures of the basic elements to give a greater sense of realism, the movement of pedestrians within an urban space in a 3D environment, the noise of an urban environment, natural lighting (solar access) of an urban space and the effects of wind within an urban environment. From the systematic review of VR engines, CryEngine was chosen for use within the research.

5. VALIDATING SOFTWARE APPLICATION

The methodology used to identify and filter software applications capable of 3D modelling, thermal analysis, wind analysis, noise modelling, pedestrian movement and virtual reality (Figure 2), selected six software applications considered appropriate for use within the research; Google SketchUp, TownScope, Star-CD, CadnaA, Legion Studio with Legion 3D and CryEngine. However, before each of the selected software application could be accepted for use within the research, it was crucial that the selected software were successfully and thoroughly evaluated. The evaluation of the software was done by trying to simulate real-world characteristics of a selected city centre square within Birmingham and by the means of established criteria. The established criteria was based upon the key requirements of the software and in a similar process adopted by Riether and Butler (2008) evaluated the software for its input and output capabilities, before presenting a summary. To meet the requirements of the software the study was expanded to also evaluate the import and export capabilities of the selected software applications**.** Although the requirements of each criterion differed slightly depending on the software being evaluated, the established structure remained. The selected software was firstly evaluated for its ability to import data from other related software applications or external sources. This process included; identifying appropriate file formats for import, establishing any necessary amendments needed to the external file before being imported, evaluating the process of importing external files and examining the results. Secondly, the ability to input relative and precise data was evaluated. This process included; identifying the data needed to be inputted into the selected software and evaluating the process of inputting data. As part of this process the software was evaluated for its ease of use and its ease to learn. The software was thirdly evaluated for its ability to produce accurate results, compared to the observed real-world data and findings established from the fieldwork carried out in the selected square within Birmingham. As part of this process the time taken to generate the results and the output format was identified. Finally, the software was evaluated for its ability to export data to the selected virtual reality software**.** This process required identifying appropriate file formats that would allow for the results to be both viewed and imported into the virtual reality software**.** The overall process was then summarised, with key findings being identified and conclusions being made about the selected software potential for use within the research. This paper presents the evaluation of three of the selected software application; Google SketchUp, CadnaA and Townscope.

5.1 3D Modelling

The city square is a particular urban element which can take many forms and its geometrical relationships such as maximum dimensions, size and location of openings, ratio of width to length and building height to length have been analysed for centuries (Alberti 1475), (Vitruvius 1550), (Sitte 1889), (Corbett 2004). The style, artificial lighting and the location of primary buildings, subspaces, art and fountains all contribute to the feel and the success of a city square.

The 3D modelling software used within this research was evaluated for its capability to model a 3D master model of a selected city centre square within Birmingham. A 3D master model would give an 3D representation of the city square, allowing for changes in geometrical relationships and aesthetic qualities to be tested.

Google SketchUp

Google SketchUp is a tool for creating, editing and sharing 3D models. Google (2009) state that SketchUp is designed for architects, civil engineers, filmmakers, game developers and related professions, and is marketed as an easy-to-use 3D modelling tool. Google (2009) state that SketchUp offers a simple interface and was designed to be more intuitive, flexible, and easier to use than other 3D CAD programs. As a result Google SketchUp promises a fast learning curve, not just for experienced 3D modellers but also for first time users.

Import

The first step in creating an accurate master model of the selected square within Birmingham, was to evaluate Google SketchUp's ability to import a plan of the selected square. The imported plan was used as a reference from which the 3D geometry of the master model could be modelled from and consisted of Ordnance Survey maps and data sourced from the Digimap service offered by Edinburgh University. The Digimap service only allows for a Jpeg file format to be saved, and as this format can be easily imported into Google SketchUp, it this file format that was used for importing the plan. As part of the import process, image files from Digimap could only be saved at a ratio of 1:500 and therefore needed to be rescaled to a ratio of 1:1 in Google SketchUp to allow for precise 3D geometry to be modelled.

Input

The modelling process in Google SketchUp is a very user friendly and intuitive process, with a user interface designed to be very simple and easy to use. The modelling process began by creating 2D planes by using a number of 2D modelling tools available, including; line, arc, rectangle, circle and polygon. When creating the master model, the 2D modelling tools were used to trace around the key outlines of the imported plan to create a number of 2D planes. To generate 3D geometry, Google SketchUp contains a modifying tool called push/pull. This unique tool only available in Google SketchUp allows for any 2D plane to be extruded into a three-dimensional form and for extruded 3D geometry to be modified with ease.

Output

By using the 2D modelling tools and the modifying tools available in Google SketchUp, users are able to create a wide variety of 2D planes and 3D geometry. When creating the master model, a combination of the modelling and modifying tools allowed for 3D massing of the selected square within Birmingham to be easily built up. The 3D massing model of the selected square within Birmingham is shown in Figure 3.

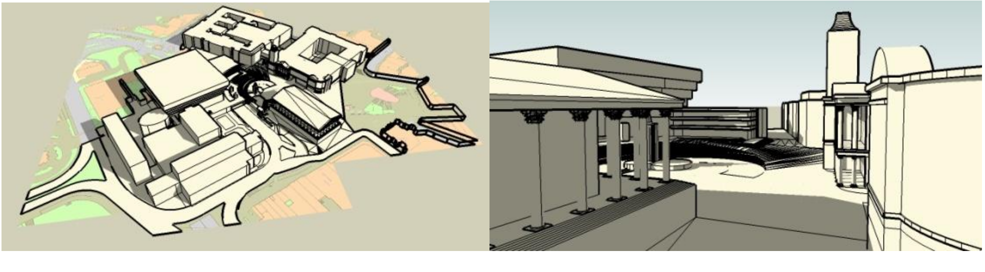

Figure 3. Massing model of the selected square within Birmingham

Export

Google SketchUp was finally evaluated for its ability to export the 3D geometry in a format that could be imported into the remaining selected software applications. The evaluation of Google SketchUp identified that 3D geometry could be exported in range of CAD formats compatible with the remaining evaluated software applications, see; Table 5.

Table 5. Compatible file formats between SketchUp and other evaluated software packages

Google SketchUp Export file formats	CadnaA Import file formats	TownScope Import file formats
3Ds		Y
DXF	Y	Y
DWG		
VRML		
FBX		
OBJ		Y

Summary

The evaluation of Google SketchUp aimed to establish if it could be adopted for use within the research. The evaluation of the software by the means of set criteria aimed to evaluate Google SketchUp capability in creating a master model of the selected square within Birmingham. From the evaluation process it can be concluded that Google SketchUp has fulfilled the key requirements set out in established criteria and was capable of creating a master model of the selected square within Birmingham. SketchUp offers a user friendly and intuitive approach to modelling and modifying 3D geometry. With a simple user interface, basic 2D modelling tools and advanced modifying capabilities, Google SketchUp allows users to create and modify a variety of 3D geometrical models. SketchUp also offers the capabilities of both importing and exporting a number of different file formats compatible with the remaining software applications (Table 4).

5.2 Noise Mapping

Both Reekie (1972) and Corbett (2004) highlight that noise, which is part of the daily assault on the senses, is one of the major if not most serious of atmospheric pollutions, stating that perhaps the most intrusive pollutant infringing on the enjoyment of a city square is the noise of motor traffic. Corbett (2004) states that sometimes vehicles cannot be removed and so consideration has to be given to ameliorating the harmful effects of traffic noise, highlighting that walls are the most effective sound barriers when they are of solid construction. However, to be effective they must be sufficiently long and high, and close to the source of the noise or to the people to be protected, therefore having great aesthetic effect on a square and upon surveillance. Thus, the arrangement of the buildings and landscaping around a square will usually be the most effective and visually appropriate means of controlling sound. Alternatively, Corbett (2004) states that where noise cannot be reduced by the placement of solid barriers, noise can be softened by the bubbling and gurgling of a water feature.

The noise mapping software used within this research was evaluated for its capability to produce an accurate real-world noise map of a selected city centre square within Birmingham. An accurate real-world noise map would identify areas within the square that were susceptible to high levels of noise pollution. Being able to identify these areas, would allow the user to test design solution for reducing of softening high levels of noise pollution.

CadnaA

CadnaA (Computer Aided Noise Abatement) is a leading software application for the calculation, presentation, assessment and prediction of environmental noise (DataKustik No Date). It will be used within the research to model and analyse the noise environment of city centre squares. Developed by DataKustik in Germany, CadnaA has many features including more than 30 implemented standards and guidelines, powerful calculation algorithms, extensive tools for object handling, the ability to import and export information from Google earth, 3D visualization and a very user-friendly interface (DataKustik No Date). CadnaA is also able to communicate with other Windows applications like word processors, spreadsheet calculators, CAD software and GIS-databases. Another facility in CadnaA is the Dynamic 3D environment which allows the user to drive through or even fly over a project model.

Import

CadnaA, was firstly evaluated for its ability to import the master model of the selected city centre square within Birmingham. Although it was established that both software applications shared the same file format, the process of importing the master created in Google Sketchup into CadnaA proved more difficult than anticipated. Before the master model could be imported into CadnaA, amendments to the master model needed to be made. Appropriate layers within the model were modified so that they closely matched the corresponding CadnaA-object types. The master model was divided into five key layers; buildings, roads, columns, walls and floorscape. However, the last two layers; walls and floorscape did not have a direct corresponding CadnaA-object type, the nearest and most appropriate match was to assign the wall layer to the barrier object type and the floorscape layer to the contours object type. The lack of a direct corresponding CadnaA-object type for the floorscape layer identified a major problem with the software. The inability to split up the floorscape into more defined elements, i.e. steps, ramps and floorscape, due to the lack of CadnaA-object types resulted in the whole of the floorscape being imported on the object type ‘contours’. By importing the floorscape into CadnaA using this object type, the modelled floorscape could not be accurately generated. Another major problem identified, was getting the noise mapping software to generate the buildings automatically in 3D. CadnaA did allow for some buildings and some parts of other buildings to be generated automatically in 3D. However, the problem of getting the remaining buildings to be automatically generated in 3D could not be resolved and resulted in the remaining 2D buildings to be manually generated in 3D by inputting the height data for each of these buildings individually. Due to CadnaA failing to import the master model correctly, the study could not continue the evaluation of the software.

Summary

The evaluation of CadnaA’s capabilities to meet the criteria set out by the research was not completed due to the key requirement of importing the master model created in Google SketchUp being unsuccessful. Although the testing of the software identified a number of problems in importing the master model that could be resolved by a manual input of data, the failure to resolve the problem of importing the master model, due to a lack of object-types resulted in the failure to import the master model. CadnaA's inability to produce the detail in the environment that the research required of the software, resulted in the evaluation and testing of the software to stop and for CadnaA not to be considered for use within the research.

With CadnaA being considered not appropriate for use with the research, the previous selection process used to identify the noise mapping software was re-examined. The study identified that CadnaA is certainly a very powerful and sophisticated noise mapping software, however, on reflection of the problems encounter during the evaluation, it was established that CadnaA is more suited for analysing the noise environment at a macro scale and is not capable of modelling the detail required at a micro scale. The study both re-examine those software applications previously identified but that were not considered, as well as identify new noise mapping software applications for their ability to model and analyse noise at a micro level. By repeating the identification and selection process for noise mapping software, taking into account those capable of analysing noise at a micro level, the study selected the software application Raynoise for possible use within the research. However, the evaluation of this software application has yet to take place and is therefore not presented in this paper.

5.3 Thermal Comfort

The microclimate of a square is an important issue in its design. In creating a square that is comfortable to be in, temperature and humidity should be greatly considered and are two of the important factors upon which human comfort depends (Reekie 1972). The amount of solar access within a square and the surrounding surface materials contribute significantly to the temperature of the air within a public space. The choice of surface materials within the square and on the buildings around it should therefore be guided by the objective of avoiding extremes of microclimate. Corbett (2004) highlights that materials need to quickly absorb and store excess heat and quickly release the heat again when temperatures fall. It is essential that in temperate climates, city squares receive as much direct sunlight as possible, while shelter from the rain and wind should also be readily available (Marcus, 1998) (Corbett, 2004). Sunlight penetration into urban places can also aid in making squares more pleasant places, not only by increasing the temperature but by also providing natural lighting, which makes an important contribution to the character of public space, as well as aesthetic dimensions (Carmona, 2003). The value of sunlight penetration varies over the seasons and, while places in the sun are desirable at some times of year, at other times shade is preferred, although overshadowing should be avoided during winter months. The height of surrounding buildings and trees and the spacing between buildings all play a significant role in the amount of solar access within a city square.

The thermal comfort software used within this research was evaluated for its capability to produce an accurate real-world thermal comfort and solar access map of a selected city centre square within Birmingham. These accurate real-world maps would identify areas within the square that were susceptible to high or low temperature and solar access levels. Being able to identify these areas, would allow the user to test design solutions; height and location of buildings and trees and choice of materials, for reducing or increasing temperature and solar access levels.

TownScope

TownScope will be used primarily in the research to analyse and simulate; solar access and thermal comfort of city centre squares. The features of the software include the ability to; import both 3Ds, DXF and OBJ file formats, add meteorological parameters (humidity, clouding, etc.) and vegetation masks specified as monthly data, create terrain from 3D points and the ability to render opacity and daylight shadings (Azar 2007).

Import

The evaluation of TownScope began by evaluating its capability to import the master model of the selected square within Birmingham. From evaluating the software against the set criteria, it was established that TownScope could easily import geometry data from the 3D modelling package Google SketchUp. The study identified that TownScope supports several file formats for importing the 3D geometry data (Table 5). To identify which file format showed the most potential for use within the research, the study examined the geometry generated from importing the identified file formats (Figure 4). From this examination process the study indentified that the file format DXF was the most appropriate for importing 3D geometry data into TownScope. Geometry imported with the 3Ds file format contained missing faces and could not be used to successfully analyse the space. The geometry imported using the OBJ file format contained more faces then the original master model, increasing the difficulty in assigning data to the model and in the time taken to carry out any analysis.

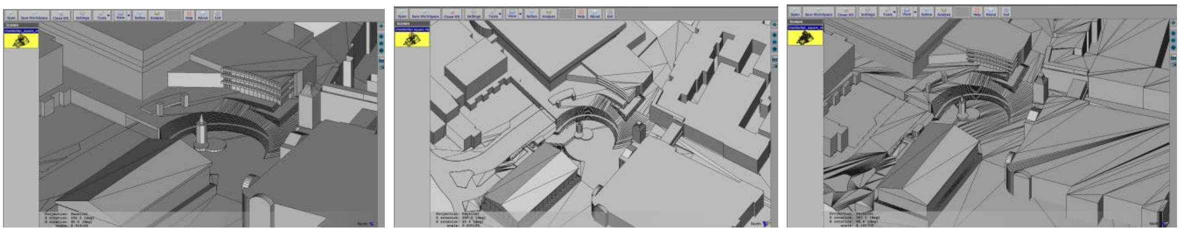

Figure 4. Imported model using different file formats (3Ds, DXF, OBJ)

Unlike the noise modelling software that required the setting up of layers to correctly generate the master model, TownScope requires no such input. The only process required prior to importing the master model is to rescale the dimensions of the model to metres. This is due to the master model being drawn using millimetres and Townscape using metres.

Input

The study identified that for TownScope to produce accurate results, it must be evaluated for its capability to accurately define the longitude and latitude of the selected square, the North axis, the time of year under investigation, weather conditions, air temperature, wind speed and properties of the materials within the square. The evaluation identified that TownScope could accurately input and define the necessary data. However, the software did not contain an accurate database of materials and their corresponding properties (absorption and reflection, etc) or values for preset weather conditions (humidity, clouding rate, etc). Therefore, for TownScope to be used effectively to produce accurate results, a database of material properties and values relating to weather conditions needed to be established. The study identified that historic weather data for the UK can be obtained from the database available from the British Weather Service.

Output

Once the accurate data had been inputted into TownScope, the software was evaluated for its ability to produce accurate results. The software was firstly evaluated for its effectiveness in producing the results by examining the time it took to complete the different analyses and the output format. Due to the complexity of the selected square and therefore the complexity of the master model, solar access analysis took 11 hours 42 minutes to complete and thermal analysis took 22 hours 14 minutes, using one standalone computer. This amount of time is unpractical to effectively use the software to aid in the design of city centre squares. However, the software is regularly being revised to improve the analysis process and along with improvements in computer power (Moore's law), these will aid in reducing the analysis time. Once the analysis of the solar access and thermal was complete, results can either be viewed in a table format or can be displayed by the means of a multi-coloured map that follows the contours of the model (Figure 5). The study then aimed to compare the results produced by TownScope with the observed real-world data and findings collected from the fieldwork. However, due to limitations in the demo version used to evaluate the software, results could only be produced for one day of the year, June 15th. Therefore results could not be compared to the observed real-world data and findings collected from the fieldwork.

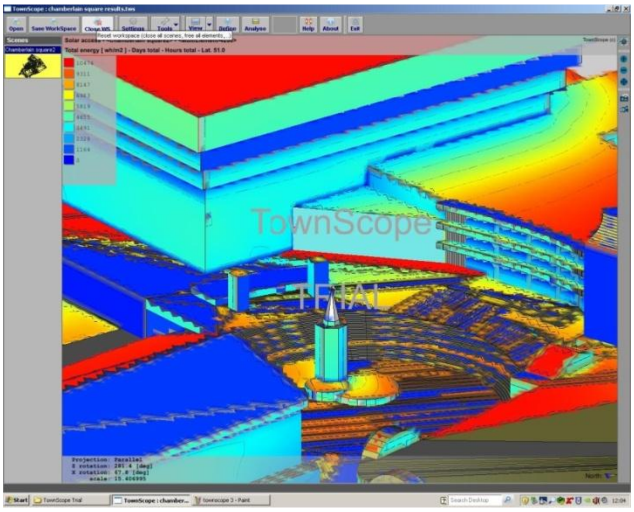

Figure 5. Solar access results produced by TownScope

Export

TownScope was lastly evaluated for its capability to export the results in an appropriate format that could be inputted and viewed within the virtual reality software. By evaluating TownScope capability for exporting data, the study identified that the version of the software being evaluated only offered the ability to export results into a text format. This is not an appropriate format to view the results within the selected virtual reality software. Therefore this version of TownScope does not allow the capability to export results in a format appropriate input into the virtual reality software.

Summary

In summary, the evaluation process aimed to establish if TownScope could be adopted for use within the research by establishing the software capability to meet a number of key requirements by the means of set criteria. From the completion of the evaluation process it can be concluded that TownScope can be adopted for use in the research. TownScope could successfully import the master model and input and output data. Although, the current version of TownScope does not allow for the results to be exported in a format appropriate for input into the virtual reality software, there is a lack of another software application capable of thermal and solar access analysis using 3D representation. The evaluation process also identified that for TownScope to be used effectively in designing city centre squares a database of material properties and values relating to weather conditions needed to be established. The study identified that historic weather conditions for the UK could be accessed via the British Weather Service website.

6. CONCLUSION

This paper identified that there was a need for a holistic approach to urban design and proposed that with the ability to analyse and simulate different aspects of urban design using three dimensional representations, will aid urban designers to improve the quality of city centre squares. The paper aimed to identify, select and evaluate software capable of analysing and simulating a number of urban texture and urban quality aspects. The study adopted a systematic review and filtering process to effectively identify software applications considered appropriate for use within the research. By comparing the remaining software applications against the original criteria the study selected one software application for each of the established six categories (Figure 2.). However, before each of the selected software application could be accepted for use within the research, it was crucial that the selected software was successfully and thoroughly evaluated. Established criteria were used to evaluate three of the selected software applications in relation to the requirements of the software and by trying to simulate real-world characteristics of a selected city centre square within Birmingham. The established criteria aimed to evaluate the selected software in four key areas; import, input, output and export. From the evaluation process it can be concluded that Google SketchUp and Townscope could successfully be adopted for use within the research. However, the evaluation of CadnaA established that it could not be adopted for use within the research as it was unable to model the noise environment at a micro scale level. By repeating the identification and selection process for noise mapping software, taking into account those capable of analysing noise at a micro level, the study selected the software application Odeon for possible use within the research. The evaluation of this software application has yet to take place and is therefore has not been presented in this paper.

The evaluation of the selected software applications has identified a number of errors both within the original selection and filtering process and within the software applications themselves. However, the research has established there have been limited attempts at combining a number of software applications in the design of city centre spaces. Therefore the process of implementing several software applications in the manner proposed by the research, along within software applications themselves is understandably to have faults at this stage of the research. A process of redefining and improving the connection between selected software applications will therefore continue throughout the research. The paper concludes by proposing that by incorporating the selected software applications into the urban design process will allow urban designers to effectively test and develop their designs. It is proposed that this will aid in the improvement of the design of city centre spaces and the comfort of users within the spaces.

7. AREAS OF FUTURE RESEARCH

This paper only presented the evaluation of three of the six selected software applications. The study will therefore continue to evaluate the remaining selected software for their use within the research. The research then plans to examine and evaluate the design and comfort levels of five selected Northern European city centre squares, by using knowledge gained from reviewing notable urban design literature relating to the design of city centre squares and applying the final six selected software applications. Knowledge gained from reviewing and evaluating five selected Northern European squares will be combined with previous knowledge gained from reviewing notable urban design literature to aid in the design of a group of connected city centre squares for Newcastle-Upon-Tyne. The proposed design of a group of connected city centre squares will be used as a demonstration of the selected software applications use within the urban design process and a holistic approach to urban design.

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Bio

After completing an undergraduate degree in Architectural Technology at Northumbria University, I was offered the chance to carry out a PhD research project within the school of the built of environment. The research proposed would look at the use of 3D modelling and virtual reality software application within the urban design process. Currently in the final year of study, the research has been focused to examine a holistic approach to the design of city centre squares, using three dimensional representations.