STATE OF THE ART 3D DESKTOP SIMULATIONS FOR TRAINING, FAMILIARISATION AND VISUALISATION.

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ABSTRACT

Continued advancements in the power of desktop PCs and laptops, combined with advanced software, digital photography and laser scanning have enabled the growth in use of 3D visual simulations in training with significantly more realism and interactivity than before. 3D Visual Simulations Ltd are at the forefront of this technology and will demonstrate applications developed across a number of industries for spatial awareness and procedural training, with particular relevance to the fire and rescue services.

INTRODUCTION

A simulation is an imitation of a real thing, state of affairs or process. Generally this entails representing key characteristics of an abstract or physical system. An interactive simulation is a special kind of simulation often referred to as 'human in-the-loop' simulation which includes human operators. Typically such simulations are created using computers and allow an operator to interact with some kind of *virtual environment* in a manner consistent with physical laws. The operator receives information from the virtual environment via their senses and operates controls to interact with the simulator. Interactive simulators are most commonly used to train the drivers of vehicles and operators of complex machinery, but are increasingly finding more widespread applications. Vision is the most common sensory feedback reproduced, which is required for almost all simulation tasks, audio cues are next followed by force-feedback controls and motion of the operator. Least common is smell although it is used in some applications. The level of realism that the simulator can reproduce the real-world is referred as its *fidelity*. The fidelity required depends on the task. For example, training a student to control a vehicle is a task which requires a high level of simulator fidelity - motion of the operator is required to reproduce the sensation of braking and realistic feedback from the steering wheel is required to sense cornering forces on the vehicle. However, training initial familiarity with the functions of the controls and the rules of the road can be successfully done with only visual feedback and a standard keyboard and mouse, at a much reduced cost.

Increasing the fidelity of a simulator usually implies higher capital and maintenance costs. Although a higher fidelity simulator may deliver better training, budgets are finite so for the same capital expenditure many lower fidelity simulators could be purchased, which may deliver better training to the whole workforce than a small number of better simulators with limited availability. In the UK rail industry approx £50m has been spent on high fidelity full-cab simulators, however the current trend is to move all of the elements of driver training that do not require the full fidelity onto low-end PC based simulators in order to improve access and maximise the training benefit of the investment.

EFFECTIVENESS OF SIMULATION FOR TRAINING

The effectiveness of an interactive simulation can be determined by the level of belief that the operator has that they have left the real world and are now present in the virtual environment. This is referred to as 'immersion' and is usually correlated with fidelity. The more *immersive* a virtual experience, the greater the sense of being part of the experience. It has been suggested that a sense of immersion contributes to the effectiveness of learning, comprehension, insight, performance and transfer of training in a simulator [1]. This could certainly be said to be the case for emergency services commanders where a major aim of the simulated training is learning to cope with a highly stressful situation. However, the relationship between immersion and training performance may be causal or correlational – since both are likely to be inextricably linked to simulator fidelity.

Simulation for training

The simulator has to have an adequate level of fidelity for the task. If the simulator is not realistic enough to train for the task required, *negative training* may result where the trainee learns to perform an action to complete the training task which does not apply to the real situation. For example studies have shown if a trainee learns to drive a vehicle in a simulator without motion force feedback they frequently learn to brake harder than they would in a real vehicle due to the lack of deceleration feedback [2]. The training learned on the simulator will thus not transfer well to the real vehicle and may even hinder the trainees ability to learn to drive the vehicle. The solution is to limit the training tasks handled by the simulator to ones that can be adequately reproduced.

Stages of training

Broadly speaking training can be divided into 3 stages

- Initial training is where the basics of operating the equipment are taught and the rules governing its use.
- Advanced training focusses on higher level skills such as strategies & planning, and spatial awareness
- Special procedures deal with situations which do not occur frequently but require a different approach or procedure such as equipment failures or 'worst case scenarios'.

Simulation can be used at all stages of training. For initial training simple low fidelity simulators running on standard desktop PCs can be effective since we are only training familiarisation with the control layout and the effect of the controls. This applies both to new trainees and where new equipment is being introduced or upgraded. For advanced training generally higher fidelity simulators are required which reproduce a wider visual field-of-view, more realistic physics being required if negative training is to be avoided. In the emergency services and the military the trainee must experience a high level of stress.

In the vehicle simulation community the term 'transfer of training' is used to indicate how well skills learned in the simulator transfer into the real world. Effectiveness of transfer can be evaluated by measuring how many runs in the simulator are required to reach a set level of proficiency in the task as compared to training using the real equipment [3]. This is the approach used in flight simulation, however it assumes the task being trained can be done safely with the real equipment, which with special procedure training is usually not the case.

Familiarisation and visualisation

3D Visual Simulations specialises in highly visually realistic simulations which are targeted at standard desktop computer hardware meaning they can be cost effectively deployed. To construct the visual database we employ photogrammetric methods to ensure the 3D model appears as realistic as possible, thus maximising the training benefit. The most common applications of the technology are familiarisation and visualisation. Familiarisation concerns training familiarity with either a location or a piece of equipment which is not readily accessible, usually for logistical reasons. Fire and rescue personnel have an obvious need to be familiar with the layout of structures where they may be required to work under emergency conditions however there are many less obvious examples where the same need arises. Most recently we have developed a familiarisation application of an abattoir for Veterinary students. In familiarisation the 3D model itself is the object of the training exercise, whereas in visualisation it is other 3D data which is important, the model being used as a framework to show the nature of the data. Image data such as thermographic survey images or security camera video can be visualised in 3D by projecting the data onto the 3D model from the position the camera occupied when the data was captured. The 3D model can also be used as a basis to capture expert knowledge about, for example, crowds responding to an incident or the behaviour of fire when treated with an agent by a fire-fighter. In these cases the expert can ensure the behaviour exhibited is unambiguous and is the correct behaviour to get the training message across as clearly as possible.

CASE STUDIES

Aircraft fire fighting – familiarisation of aircraft layouts

Legislative requirements state that an aviation fire fighter needs to be familiar with the layout and location of emergency equipment on all aircraft which operate at the airport which they are stationed. However due to the short turn-round time of commercial aircraft operations it is logistically very different to get sufficient access to permit fire crews to familiarise themselves with the huge number of different aircraft types that can operate at large airports.

3DVSL developed a desktop simulator from a detailed photographic survey of a Boeing 757. The simulator included the operation of all doors, location of ovens, cockpit controls of relevance, cargo hold etc (figure 1). It also featured optional reduced visibility simulating a smoky environment, and captured the difficulty of passing through small spaces with a BA system. The aim is to establish a library of aircraft types and variants which could be used by fire fighters around the world.

Figure 1: Aircraft door mechanism and catering oven.

London Underground – visualisation of crowd problems.

Wembley Park Station is adjacent to Wembley Stadium and is the primary route for football fans visiting stadium events. On an event day upwards of 60,000 fans can pass through the station in 90 minutes, requiring careful coordination to manage the flow. Extra staff need to be drafted in from across the LU network and they may not necessarily be familiar with procedures in place. Although most will be familiar with crowds they may not be prepared for the issues with such a high crowd density, and particularly the speed at which a dangerous situation can develop when an incident occurs. In addition, the geography of the station poses certain problems since there are steep steps leading up to the station from the stadium walkway.

3DVSL developed an accurate 3D model of the station which could firstly be used for familiarisation with the station layout and evacuation routes, and secondly could be used to visualise where crowd problems can develop in a variety of scenarios. Although crowd modelling packages are widely available (and were used in the design of the station) it is difficult to use the simulation results for training since they are not flexible enough to answer 'what if' questions, and perhaps more importantly if they are not very carefully set up the results of the simulation may not clearly demonstrate the training message! To address this we developed an interactive tool which could be used to 'paint' crowd densities onto the model which would be visualised with the appropriate density of human avatars (figure 2). An expert familiar with the station and training requirements can easily create a number of crowd scenarios which demonstrate problem situations such as train failure, crime incidents, fire, station closure etc. The application is in constant use and the British Transport Police have expressed an interest in including policing issues.

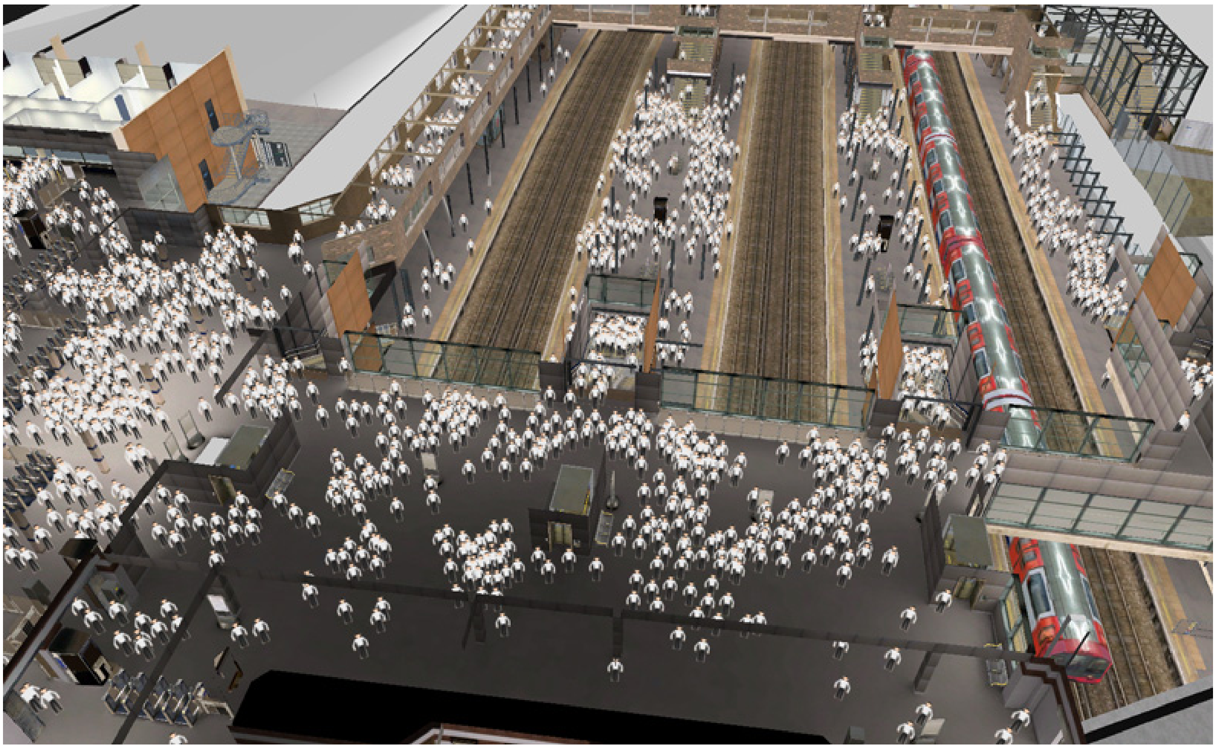

Figure 2: Crowds visualisation guided by domain expert input.

Strathclyde Partnership for Transport – equipment procedure training.
SPT operate trains, buses and the metro system in Glasgow UK. The metro consists of an underground double 10km loop with an above ground stabling shed and maintenance depot. The trains are over 30 years old and the drivers are required to perform a pre-start maintenance check of over 100 points before bringing the train into service. Due to the small size of the train cab it is not possible to accommodate more than one trainee and an instructor into the cab at any one time. This was proving a training issue due to the large turn-round of drivers and high passenger loadings resulting in difficulty of access to trains for training.

3DVSL developed a virtual train for teaching of the pre-start check (figure 3). The application works in such a way that the driver has to successfully complete each check before they can move on to the next. As such, it is not a simulation of all the train systems but more of a task trainer. One unforeseen benefit of the application has been the ability of management to analyse their procedure for the pre-start check around a table which has resulting in several improvements and streamlining of the whole procedure.

Figure 3: The virtual SPT train cab with instruments and controls..

DISCUSSION

Simulation is a well-established technology currently used for training in a number of industries. Although the training of certain procedures such as vehicle control does require a high fidelity simulator, there are many tasks which can successfully be trained with off-the-shelf PC hardware at reasonable cost and with much greater accessibility.

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