Training Simulations for Crime Risk Assessment

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***Abstract*—The purpose of this paper is to review training simulations for crime risk assessment and to discuss the system architecture of a Training Simulation (RiskMan). Computer aided training systems offer a flexible and cost-effective method for learning new skills. The satisfactory management of risk situations involves risk identification, the development of risk handling strategies and plans and the conduct and monitoring of those plans. Recognising the importance of tacit knowledge, scenario-based training has gained importance in recent years. For example, USA General Accounting Office (GAO) released a report on Homeland security titled Risk Management approach can guide preparedness efforts. This report provides a list of risk assessment measurements for contingency plan development and a matrix for risk-based scenario development. In this paper, integrating traditional scenario-based training with desktop VR systems using game engineering, we investigate how a virtual reality training system, which draws on research in the areas of computer games, knowledge acquisition, agent technology and natural language processing, can provide a safe learning experience to assist acquisition of the necessary tacit knowledge. The aim of RiskMan is to train police officers to handle high-risk situations. RiskMan is an ARC Discovery project carried out by the Department of Computing in Macquarie University. RiskMan has been developed using a very-high level scripting language of a game engine, Unreal Tournament 2004. It is composed of modules such as a Scenario-based Expert System, a Narrative Engine, a Game Engine, and a CAD package. RiskMan uses socket connections to feed information between the Narrative Engine and Sim Master to Unreal Tournament Game Engine (UT2004)..**

***Index Terms*—Games, Training, Simulation, Risk Analysis**

I. Introduction

In this paper, integrating traditional scenario-based training with desktop VR systems using game engineering, we investigate how a virtual reality training system, which draws on research in the areas of computer games [14,15], knowledge acquisition [13, 24], agent technology [22] and natural language processing [7, 25], can provide a safe learning experience to assist acquisition of the necessary tacit knowledge. The tacit knowledge that is to be taught in this training simulation is knowledge that cannot be read from a procedures manual.

The purpose of this paper is to review training simulations for crime risk assessment and to discuss the system architecture of a training simulation (RiskMan: Risk Management system). The objective of RiskMan is to help train police officers to handle high-risk situations. RiskMan is an ARC Discovery project carried out by the Department of Computing in Macquarie University [2,8]. RiskMan has been developed using a very-high level scripting language of a game engine, Unreal Tournament 2004.

RiskMan links three research projects carried out by the Department of Computing, Macquarie University and sponsored by the Australian Research Council (ARC):

- an ARC Discovery Grant (DP0558852 titled Risk Management Using Agent Based Virtual Environments) to Dr Debbie Richards, Dr Manolya Kavakli, and Dr Mark Dras,
- an ARC Linkage International Grant (LX0560117 titled An Interactive Drama Engine in Virtual Reality) to Dr Manolya Kavakli, Prof Catherine Pelachaud, and Dr Nicolas Szilas, and
- an ARC Linkage Grant (LP0216837 titled Cognitive Modelling of Computer Game Pidgins) to Dr Manolya Kavakli, Prof Terry Bossomaier, and Dr Mike Cooper.

II. COMPUTER AIDED TRAINING

Computer aided training systems offer a flexible and cost-effective method for learning new skills. Simulations can be categorized in two main groups: Experiential and Symbolic. Experiential simulations that help problem-based learning place the learner in a particular scenario and assign the user a role within that scenario. The user takes on the role and responsibilies in a virtual environment. As a result, the user gains valuable problem solving and decision making skills. On the other hand, symbolic simulations depict the characteristics of a particular system or process through symbols; and the user performs experiments with variables as a part of the program. Symbolic simulations present the user with a scenario. The user then formulates a response to the situation and receives corrective feedback. Many computer based training programs include this type of simulation.

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The satisfactory management of risk situations [6] involves risk identification, the development of risk handling strategies and plans [21, 15, 16] and the conduct and monitoring of those plans. Risk management requires the use of both codified and tacit knowledge. Our aim in RiskMan is to create a multi-agent system prototype that will allow tacit knowledge (practical know-how) to be expressed openly or taught directly.

Recognising the importance of tacit knowledge, scenario-based training has gained importance in recent years. For example, USA General Accounting Office (GAO) released a report on Homeland security titled Risk Management approach can guide preparedness efforts [6]. This report provides a list of risk assessment measurements for contingency plan development and a matrix for risk-based scenario development. In this paper, we integrate traditional scenario-based training with desktop VR systems using game engineering.

The use of game engineering to develop a training simulation is widely employed by the U.S. Military [17]. In 1999, the U.S. Army established the Institute for Creative Technology (ICT) to explore the use of commercial entertainment technology and content for military training and education [18]. The ICT is working with STRICOM and commercial game-development companies to create training simulations. The Naval War College, in Newport, has worked with Sonalysts Inc., of Waterford, Conn., to create more than 500 games [25]. Among them were three combat simulations that Sonalysts developed for distribution by Electronic Arts, of Redwood City, California, including "Jane's Fleet Command," "688(I) Hunter/Killer" and "Sub Command." The Army's Armor Center, at Fort Knox, Ky., has licensed "TacOps," a commercial clone of "Janus," a noncommercial military simulation, for company and battalion war gaming. The Army Command and General Staff College, at Leavenworth, Kan., uses a strategy game called "Decisive Action," originally developed for corps-level operations. The Naval Postgraduate School in Monterey, California developed a number of games [25] similar to commercial games Counter Strike, Delta-Force and Rainbow Six in the Modeling, Virtual Environment and Simulation (MOVES) Institute. The U.S. Army launched a computer game called America's Army over the Internet [18], developed at the Naval Postgraduate School in Monterey, California in the Modeling, Virtual Environment and Simulation (MOVES) Institute. America's Army consists of two separate games; Soldiers, a role-player based on Army values, and Operations, a shooter game that takes players on combat missions. The game accurately depicts military equipment, training and the real-life movements of soldiers. The Institute for National Strategic Studies, at the National Defense University in Washington, D.C., employs a game set in ancient Greece to teach grand military strategy. So widespread has the use of such games become that the U.S. Air Force's Air University, headquartered at Maxwell Air Force Base, Ala., every year sponsors a conference to bring together the military and commercial war gaming community [18].

More recently, the Army's Soldier Systems Center, in Natick, Massacusetts, has decided to use immersive Virtual Reality (VR) tools in training and commissioned the games developer Novalogic California, to modify the popular Delta Force 2 game to help familiarize soldiers with the service's experimental Land Warrior system [18]. The Land Warrior system includes a self-contained computer and radio unit, a global-positioning receiver, a helmet-mounted liquid-crystal display and a modular weapons array that adds thermal and video sights and laser ranging to the standard M-4 carbine and M-16A2 rifle. A customized version of another computer game, Microsoft Flight Simulator, is issued to all U.S. Navy student pilots and undergraduates enrolled in Naval Reserve Officer Training Courses at 65 colleges around the U.S.A. [25]

[16] developed a Virtual Crime Prevention through Environmental Design Kit (Virtual CPTED). CPTED is the body of guidelines that define and regulate the way in which physical environments be organized. For example, the kit produced by [21] enables trained and experienced raters to identify and quantify the crime risk, situational hazards and social conditions that are believed to attract and/or facilitate criminal behavior. [16] developed a virtual environment applying the CPTED guidelines from [21]'s kit and assessed the usability of the virtual risk assessment kit. Their experimental results indicate no significant differences in crime risk assessment within the physical and virtual representations of the world. Virtual CPTED kits provide a suitable ground for making appropriate decisions before the physical construction of the proposed environment. They used EON Reality, a virtual reality system to integrate various components within a compact system. These components include a database, a CAD package, virtual reality hardware and software.

A good example of university and industry collaboration is the development of ExpertCop [12]. ExpertCop is a training simulation for police officers who configure and allocate an available police force for a selected urban region and then interact with the simulation. Similar to the military simulations, the goal of the training in ExpertCop is to induce members of the police force to reflect on resource allocation to prevent crime. The simulation allows to observe how crime behaves in the presence of the allocated preventive policing. The training simulator receives a police resource allocation plan as input, and it generates simulation scenarios of how the crime rate would behave in a certain period of time. The objective is to lead the police officer to understand the consequences of the allocation performed as well as understanding the cause-and-effect relations. ExpertCop [28] performs the interactions of police teams and criminals in a game-based virtual environment , including a pedagogical tool that implements and explains interaction strategies between the police officer and the simulator. The pedagogical tool is designed to better understand the simulated phenomena. The simulations occur in a learning environment along with graphical visualizations that help the police officers learning. The system allows the student to manipulate parameters dynamically and analyze results. The system uses Problem Solving Methods to support the development of KBSs by using the Unified Problem-Solving Method Description Language (UPML) [10].

ExpertCop is not the only computer aided system addressing expert systems in training simulations. To inform the jurors, Federal and US State Court use Force Case law on searcable CD disc, the 13th Juror disc [9]. The 13th Juror disc contains searchable case law [9], Use of Force Policies, FBI articles, Use of Deadly Force case law, OC spray case law, Pursuit case law, and Police Studies. The 13th Juror disc contains 3,900 files. The goal of this CD is to inform a police officer about the law, before he/she performs a lawful seizure. Expertcoplaw discs contain the full case review of over 3,900 Police Procedures and Practices cases from around the United States. United States Supreme Court, Federal Courts, and State Courts are represented.

The use of VR for training has become a major focus in academic communities as well. Two noteworthy projects are the Net Environment for Embodied Conversational Agents (NECA) [19] supported by European Commission in order to develop conversational agents that are able to speak and act like humans and the Mission Rehearsal Exercise System (MRE) [28] supported by US Army in order to develop an immersive learning environment where the participants experience the sights, sounds and circumstances they encounter real-world scenarios. While both projects seek to build intelligent agents that are able to respond and adapt to their environment in natural and believable ways, NECA's primary focus is on natural language and emotional agents whereas MRE's primary focus is on movie-like realism. Such large-scale projects involve major costs in time, technology and human resources beyond the reach of most organisations. Commercial simulation environments that are currently available offer minimal user interaction, cannot be used to define complex training scenarios, and use scripted characters that cannot react appropriately to the user or the events.

III. SYSTEM ARCHITECTURE OF RISKMAN

RiskMan is composed of modules that separate the data models and functionality. The major modules are a Scenario-based Expert System, a Narrative Engine, a Game Engine, and a CAD package. In keeping with good design practice, we will keep coupling of modules to a minimum while seeking high cohesion within individual modules. Our architecture is given in Figure 1.

RiskMan uses socket connections to feed information between the Narrative Engine or Game Master Control to UT2004 and vice versa. In this case both the Narrative Engine and the Game Master Control are external client programs controlling the decisions of the NPCs actions such as walk, run, turn and talk. Socket communication has been set up having Unreal as being the server application, and a Java application as the client connecting to Unreal over a TCP connection.

A modification in the game world, also known as a mod, is the alteration to a game to make something within the game function in a different way to which it was originally specified. RiskMan, for instance, is a mod to the game Unreal Tournament 2004 (UT2004) which is expected to work as a first-person-shooter game. Instead, RiskMan modifies UT2004 so that it can be used as a first-person training simulation.

RMM is a level in this training simulation created for people, such as customs officers and police officers[1], dealing with high-risk situations [26]. The RMM simulates a virtual world where the trainee interacts through an immersive first-person perspective. The trainee interacts with each of the characters in the virtual world via conversational speech bubbles. The other characters in the virtual world can be controlled by a Narrative Engine providing the Artificial Intelligence, or by a human using a Controller Interface. A list of the functionalities of the RMM includes:

- The ability to spawn and control non-playable characters (NPCs) through an external client program.
- Allows for any map to be used.
- Allows for import of custom characters.
- Allows for the activation of custom animations.

A. Scenario Based Expert System

A research project sponsored by the National Institute of Justice, U.S. Department of Justice (grant award number 2000-IJ-CX-0009) suggests a number of actions for the development of risk assessment tools [1].

Some of these are summarised as follows:

- A risk assessment tool should be comprised of 17 variables in six categories: economic factors (4), government (3), law enforcement (4), social/technological change (2), criminal environment/special skills (3), and potential harm (1). These six categories of factors are most likely to affect the nature and extent of organized crime.

- There are four parameters for an organized crime risk assessment tool to be useful in practice. It must be location-specific (i.e., findings will vary by geographic location), activity-specific (i.e., different activities will have different risk levels), time-specific (i.e., conditions change over time so risk assessment must done periodically), and all factors must be measured comparatively against levels found in other jurisdictions.

- A "team" approach to risk assessment, involving police, analysts, and researchers, is an exemplary arrangement for organizing the information needed for application of an organized crime risk assessment tool. The types of data and analysis needed (intelligence, arrest/group trends, surveys, economic data, harm estimates) require the contributions of each of these groups.

[1] The current RMM only deals with customs officers. It can however cater for others such as police officers by modifying a few things such as a new map.

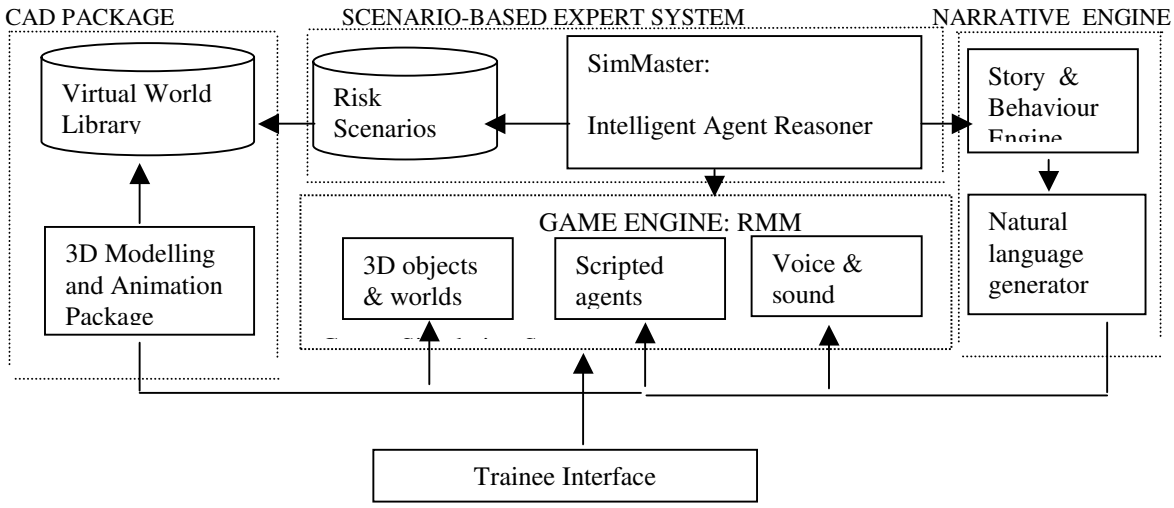

Figure 1: Risk Management Training System Architecture

As the Scenario Based Expert System Module, we aim at adopting ExpertCop Domain Model in RiskMan. The UPML Framework with the new explanation compo-nent has been used in the Expert Cop System project to develop a decision-making process KBS for a criminal agent. The system is based on a criminal geo-simulation system modeled for a specific region. This system uses the Multi-Agent Systems (MAS) technology to simulate social environments. In the project, the KBS developers reused UPML generic components, the explanation component, and the classes implementing the abstract-and-match PSM. Developers implemented the following domain classes:

- • *CrimeSituation* representing data about the environment at the moment of the assessment of the criteria.
- • *CriterionCrime* representing criteria to be evaluated such as risk level, opportunity, crime level, criminal danger, etc.
- • *DecisionCrime* representing the following possible decisions: “the criminal does commit the crime” and “the criminal does not commit the crime”.
- • *AbstractionRules* representing rules for abstracting case data. For example, to abstract the distance be-
- tween a police officer and a selected point in the geosimulated system as ‘close’, Expert Cop uses the following abstraction rule: “if distance < 300 meters then police officer distance is ‘close’”.
- • *EvaluationRules* representing rules for evaluating available criteria. For example, Expert Cop has the following evaluation rule for the risk level criterion: “if police officer distance is close then risk of committing a crime is high”.
- • *DecisionRules* representing rules for making a decision for the case. For example, Expert Cop uses the following decision rule: “if risk is high then decision is to not commit a crime”.

These classes represent the domain knowledge and are instantiated in the application and mapped to the PSM ontology. The domain knowledge gathered from a knowledge acquisition process with expert police personnel who know which criteria a typical criminal uses when deciding whether to commit a crime.

B. Game Engine

A game engine is a software used by game developers that handles the basic elements needed to develop a computer game. It typically includes:

- Real-Time 3D rendering engine
- Level editor
- AI representing the behavior of non playable characters
- Game elements
- Facilities to import 3D model from modeling/animation software packages

Initially, game engines were only used internally by the video game companies. The current trend of “game modifications” ("mods") consists of facilities to allow the player modify the game to make his/her own version of the game. Game engines today are released as a part of the game and included in the game's disks, free to use, in non-commercial projects.

The major advantages to use a game engine are as follows:

- It provides the best technologies regarding 3D graphics,
- It enables to focus our research on higher level processing, namely animation, behavior, and narrative.
- It may provide plug-ins to enable the use of virtual reality hardware (e.g., CAVE UT).

In this project, as mentioned in the System Architecture part, we have used Unreal Tournament 2004 Game Engine, and implemented a new mod within this game engine, called RMM. The Game Engine (UT) displays animations and performs low level behaviors, such as path planning. It also senses the virtual world and manages user movements in the world.

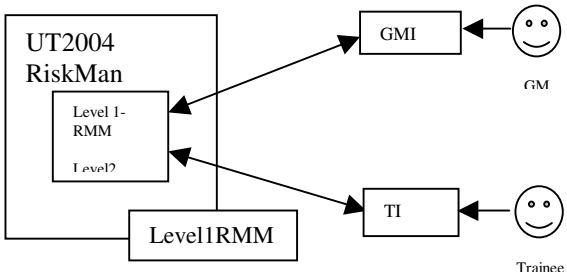

Figure 2 – Top-level Architecture

The interaction between the RMM, the GMI, and the TI is bi-directional.

C. SimMaster

The Sim Master [11] coordinate and run the simulation, controlling the NPCs and organising the events that take place throughout the simulation through the Sim Master Interface (SMI). We developed a Python program that runs a command-line SMI. The SMI is an external program to Unreal which can be run on a networked PC.

As seen in Figure 3, the Sim Master Sheet (GMsheetMap.doc on the right) portrays a top-down view of the game map/world. This top-down view also presents the location coordinates that are possible for an NPC to move to. Some of the commands for the SMI are as follows:

- **sp/<actor>/<speech>**
  Actor – is the NPC that will be doing the talking.
  Speech – is the text that will appear in the speech bubble.
- **wk/<actor>/<location>**
  Actor – is the NPC that will do the walking.
  Location – is the symbolic coordinate to where the NPC will walk towards.
- **tn/<actor>/<position>**
  Actor – is the NPC that will do the turning.
  Position – is a compass co-ordinate being either n, s, e, w, ne, se, sw or nw

D. Trainee Interface

The Trainee Interface (TI) is a GUI interface for the user that is being trained. This interface currently allows for the user to input what they want to say to the NPCs in the simulation. We developed a Python program to run TI.

E. Narrative Engine

Using UT game engine, we integrated two main modules: the Story Engine and the Behavior Engine within a Narrative Engine [27]. The behavior engine (BE) is a middle layer between the Narrative Engine and the Game Engine. It transforms the high level actions produced by the former into a set of low level animations played by the latter. The Narrative Engine (NE) is responsible for generating all narrative events, including all non playable character's actions and all possible player's actions. The Narrative Engine also includes the interface for selecting an action and the text generation module. All data related to the story are stored as external files that allow modification of the story without having to enter into the program code. In particular, XML files are used to store the structures of the narrative.

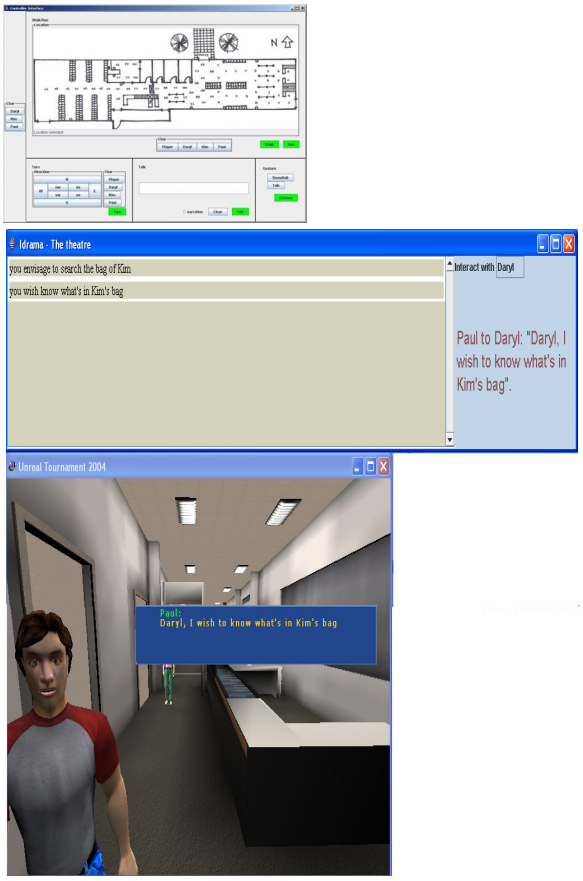

Figure 3. Risk Man Interface

Figure 4 – Trainee Interface

F. NaturalLanguage Generator

Natural Language Generator described inside the Narrative Engine is still in preliminary stage. In general, natural language generation systems start from an underlying representation of content. Their task is to decide between various realisations (e.g. syntactic, such as full sentence versus relative clause; lexical, the choice of vocabulary; or register) in order to express this content. The representations of existing systems allow for some variation depending on speaker intention and so on; however, generation is quite underspecified, not capable of producing the nuances found in speech between humans, for example the use of short clipped sentences and blunt vocabulary to express annoyance. These

can be viewed as more complex constraints of the type investigated in [7]. [25] has worked on creating specialised game slangs, which we refer to as game pidgins. Game pidgins have a potential to be considered as another rich source of data for cognitive and social linguists [14], [25]. Slang and dialects also serve to bond communities or subgroups. As a Part of RiskMan., we have attempted animating faces using RUTH (Rutgers University Talking Head) [5] and GPL (Game Pidgin Language) that we have developed [25]. Animation of RUTH affords interactive agents the opportunity to reproduce the functions and behaviors of natural face-to-face conversation. It also offers a methodological tool for developing and testing psycholinguistic theories of those functions and behaviors. The integration of RUTH with RiskMan is still in the preliminary stages.

G. *CAD package*

As a CAD Package, we have used 3Dstudio Max, a 3D Modelling and Animation Program to generate game characters/agents and a series of behavioural animations and transferred these animations to Unreal Tournament Game Engine (UT2004). [22] defined 3 types of agents: Believable (one able to show emotions and has a personality), Interactive (one interacting with a user by following the rules of face-to-face interaction) and Embodied [4] (one able to interact with the user in all modalities a human agent may use: through words, voice, gesture, gaze, facial expression, body movements, posture, etc.) They also explored emotional meaning and expressions, as well as how the cognitive and expressive analyses of communicative acts can be applied in the construction of expressive animated faces [23]. [3] defined rules for responsive robots, using human interactions to build virtual interaction that will provide fundamentals for this research. We integrate these rules to create social agents in a training system for risk assessment.

IV. CONCLUSION

Our project uses a game engine to create a training simulation RMM is a training simulation created for people, such as customs officers and police officers[2], dealing with high-risk situations. The RMM simulates a virtual world where the trainee interacts through an immersive first-person perspective. The trainee interacts with each of the characters in the virtual world via conversational speech bubbles. The other characters in the virtual world can be controlled by either a Narrative Engine, or by a human using SimMaster Interface. Within the Airport World we have created a number of scenarios for training Customs Officers [26]. The virtual airport was created using UnrealEd 3.0, which is the virtual environment editing tool that comes with UT2004. There are a few limitations that currently exist with the RMM each of which will be described in detail in this section.

1. The Sim Master Interface (SMI) can be made easier to use by allowing for voice activations[3] of the NPCs rather than a command-line interface outlined in section 5.3.4. Voice activations can be carried out by using a third-party program or using the inbuilt voice recogniser in the Unreal game engine.
2. The current Trainee Interface (TI) is an external application. This can be improved by making it part of UT2004's interface, for instance the in-game chat feature of UT2004, activated by pressing F3, allows the user to type what they want to say and output it to the screen. The TI can be modified to act similarly to the in-game chat feature.
3. Currently there are only a few commands available. In the future more commands would need to be added to activate each of the possible actions of a character, for instance, mouth movements for talking, raising of arms for a frisk and so on. Currently animations exist for mouth synching and hand movements which have yet to be activated via the code.
4. Although the SMI can be run on a networked PC, the SM currently cannot be in another room. This limitation occurs because the SM cannot see what the trainee sees without actually looking onto the trainee's monitor. A program has to be either bought[4] or created so that a networked PC can view another PC's monitor, otherwise known as mirroring. It is not possible to run the current mod in network mode to resolve the problem of SM confinement. The mod requires drastic changes to the code to enable network play.
5. The user is randomly spawned around the map according to where the spawn points/playerstarts are located. It is currently limited to spawn only in one location by having only one playerstart inside the entire airport map. Unlike the NPCs, the player's spawn point cannot be customised by using the RiskConf.ini file. Fixing this is a matter of altering the Login function inside the GameInfo class.
6. The RMM is created as a GameType mod and therefore has to be executed inside the UT2004 menus. In the future a total conversion mod would be ideal.
7. In the current version of the Narrative Engine, the XML files are edited manually. In future, authoring tool will be designed which will produce such XML files as output.
8. Using a CAD Package, we have to generate more animations capturing various gestures, more realistic characters, and new game wolrds.

[2] The current RMM only deals with customs officers. It can however cater for others such as police officers by modifying a few things such as a new map.

[3] An example of voice interaction with Unreal: http://www.scm.tees.ac.uk/f.charles/videos/index.htm

[4] Anyplace Control is an existing mirroring program http://www.anyplace-control.com/. We have tested this program on a two computers connected on a 100Mb network connection. The computer running UT2004 had a Radeon 9600 graphics card and the computer viewing the mirrored version had an onboard graphics card. This produced slightly delayed effects, possibly due to the onboard graphics.

9. Natural Language Generator described inside the Narrative Engine is in a preliminary stage and requires additional work.
10. We have to increase the number of scenarios in the Scenario Base.

We have tested RiskMan, in an initial study conducted in 2005 involving 74 third year computer graphics students. We compared the accuracy of answers to watching a training video to watching a game demonstration of the same content and found that participants perception, memory and reasoning were not significantly different using the two media [8]. A key outcome of that study, was that the participants believed that interactivity was critical for using the game environment successfully for learning [26] A second study has been approved by our university Human Ethics Committee and a pilot conducted to test RiskMan.

This paper has described RiskMan using game technology. Our goal is to build a Virtual Reality (VR) system that supports cognitive and behavioural modeling that will enable the trainee to safely and conveniently "experience" training scenarios. The third set of experiments will be conducted in our Virtual Reality Lab using CaveUT software and an immersive stereo semi-cylindrical projection system to test the learning experience.

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