The Value of Increased Fidelity of Communications Simulation in Serious Games

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Abstract. Despite rapid and continuing improvements in the fidelity of the visual systems used in serious games, the simulation of communications systems has lagged significantly. Solutions that communicate only in clear, unaffected transmissions are frequently used despite the potential for inadequate or limited training results. The immersion of participants in training scenarios is of vital importance if value from the transfer of skills and knowledge is to be achieved. For this to occur, the same level of realism is required in communications simulation as is provided in simulation visuals, physics and terrain.

1. INTRODUCTION

There can be no question as to the ubiquity and value of serious gaming in military training. The benefits due to logistical simplification, reduced danger, adaptability and importantly - cost, are well known. Synthetic training systems have evolved to a point where the acquisition of knowledge, skills and experience is at such a high level that they can be used to supplement real world training in a variety of different fields. These fields include R.O.E., hand signal recognition and reconnaissance, which are all able to leverage the advanced, complex and realistic visuals available in modern games.

Programs such as *Games for Training* and the *Dismounted Soldier Training System* in the US, as well as substantial domestic investment in serious games such as Virtual Battlespace (VBS), all contribute to the advances that have been made in simulation visuals over the past decade. The result is an increase in the value provided by synthetic training through *transfer*. Transfer is "the application of knowledge, skills and attitudes acquired during training to the environment in which they are normally used" [3] and is achieved largely through fidelity and immersion.

While fidelity and immersion in the visual aspects of serious games is very high, the same cannot be said for the simulation of communications. This paper will discuss the disparity that exists between the two, what successes have been achieved to bridge the gap and what future improvements might entail.

1.1 Fidelity and Immersion

The fidelity of the serious game, i.e. the way it "looks, sounds, and feels like the operational environment" [1] has been improving consistently for the last two decades, predominantly in the visual realm. From the early days of *Doom* with its 320x200 pixel resolution, 256 colours, 15 frames per second and 2D static textures, games have evolved to the point where one is hard pressed to differentiate between virtual representations and real life.

VBS for example, employs real-time object aggregation and object fading to provide a more believable visual experience. It uses paged-in roads technology and network optimisation to allow for more participants in larger, more complex scenarios. It also leverages Nvidia's PhysX engine to provide physics-based interactions including destructible buildings.

It is improvements such as these in visuals, game physics, textures and terrain that greatly increase the immersion of participants. Immersion refers to "the degree to which an individual feels absorbed by or engrossed in a particular experience" [5] and it is argued that it is this immersion that maximises transfer and thereby the value of the training.

Currently, the same realism is not carried through to the simulation of communications. Since real-time voice communications first became available in commercial games, this aspect of serious games has remained largely unchanged and has stagnated. This represents an environment that is entirely divorced from the reality of degraded and patchy battlefield communications.

If participants in a training exercise have to use knowledge, skill and experience to understand or extrapolate degraded battlefield communications, then they are likely to be drawn deeper into their training scenario, resulting in a greater transfer of skills and knowledge and increasing the value of the exercise.

2. WHAT CAN BE DONE?

Over the past three years Calytrix has undertaken research and development into ways in which more realistic communications can be integrated into virtual training environments. This work started with simple algorithm-only approaches and has grown to include methods that integrate deeply with the rich virtual environments present in training tools such as VBS.

2.1 Power Over Distance

In any simulation network, basic information about the state of participants is readily available. As a first step towards generating a more realistic communications environment, the location of a transmitter and receiver and the transmitter power was used to provide an approximation of signal degradation. Simple propagation models such as Hata and Friis are used to perform the same basic calculations- the further away a sender is from a receiver, the weaker the received signal is.

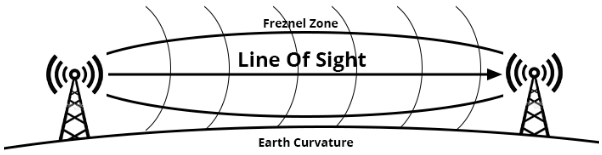

Figure 1: Free Space Signal Propagation

These calculations provide an immediately perceivable impact when deployed within serious games. Clear communications can no longer be assumed and users must contend and plan for loss of signal strength, readability and even complete communications failure.

Although simplistic, these models provide a useful and forgiving introduction to radio reception issues and are particularly aimed at participants who are inexperienced with radio use.

2.2 Line of Sight

The next step was to extract live system data from the rich games-based training environment. Information was gained by querying VBS to generate a terrain profile between the sender and receiver. This information was then used to perform Over-the-Horizon Loss (OHLOSS) calculations. These calculations take into account parameters such as the number, size and shape of intervening terrain features, radio frequency and power and effective Earth radius.

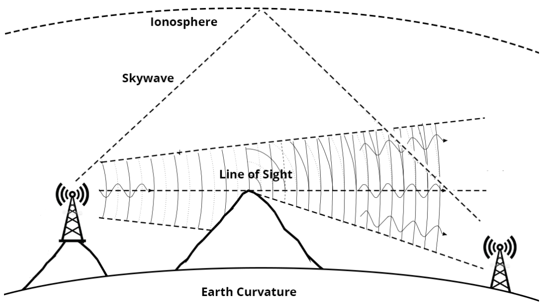

Figure 2: OHLOSS Signal Propagation

Taking this work further, additional elements of the virtual world were folded into degradation calculations. The presence of buildings and areas of foliage within the simulated world, the type of the antenna and the runtime weather conditions were all extracted and added to the calculations.

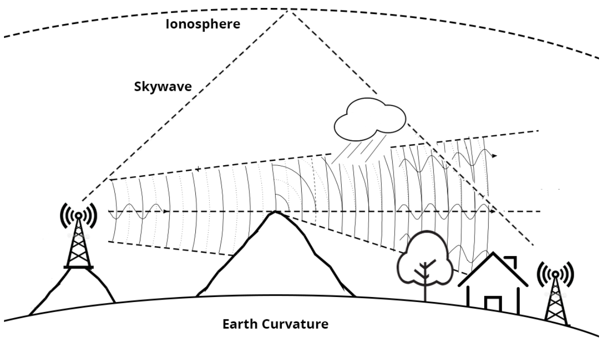

Figure 3: High Fidelity Signal Propagation

The resulting model provides greater integration between the communications environment and the virtual world. By incorporating the aforementioned parameters, a wide range of communications effects can be generated. For example, based on the signal-to-noise ratio and power at the receiver, the signal may suffer from dropouts, which cause a 'jitter' in the transmission, attenuation, which makes the transmission quieter or the introduction of noise such as 'static'.

Under these circumstances, emphasis would be placed on the participants to employ their knowledge of radio operation, signal propagation and navigation. They would need to select the optimal location and radio settings to establish or improve communications, or alter their course-of-action decisions based on the scenario presented.

In this, trainees are forced to deal with difficult situations similar to those they would likely encounter in the field, which provides for greater knowledge and skills transfer.

2.3 High-Fidelity Models

The work discussed thus far has focused on the application of open, public domain models to generate a training affect. With a pathway open between the virtual environment and the radio simulation it becomes possible to explore the use of higher fidelity models.

Calytrix's latest research and development activities have sought to go this step further. Working in cooperation with IDS UK (*Ingegneria dei Sistemi*), development has focused on combining virtual world information with high-fidelity signal propagation modeling software.

2.4 HF Skywave Model

The high frequency (HF) skywave model provides another step up in fidelity in communications simulation, for tactical HF radio, enabling training environments to mimic actual *real-time* environmental conditions.

HF skywave propagation is made possible by the presence of the ionosphere – an electrically charged region of the atmosphere, 60 km – 600 km above Earth's surface. At certain frequencies (dependent on time of day, month and year), radio waves are refracted (or bent), by the ionosphere, returning to Earth hundreds or thousands of kilometers away.

Shorter-range HF radio, using near vertical incidence skywave (NVIS), is an increasingly important option for the modern battlefield. In NVIS the transmitted energy reaches the receiver from high (near overhead) incidence angles; NVIS operations are essentially unaffected by mountainous or hilly terrain, urban structures, and other terrestrial factors such as foliage, and can provide gap-free tactical HF radio up to hundreds of kilometers in range [2], giving coverage over typical brigade operational areas.

Modern tactical HF radios (e.g. PRC-150) mitigate problems inherent with skywave propagation (coverage varying on an hourly basis due to the vagaries of the ionosphere; impossibility of relying on a single assigned frequency [4], through the use of automatic link establishment (ALE). Using ALE, available channel frequencies are constantly scanned and assessed for real-time link quality – the best available channel being automatically selected for use.

The new HF skywave model enables simulation of tactical HF-ALE radio operations, for both long range (reach back) and NVIS communications. At the heart of the model there is an appropriately detailed, physics-based, representation of ionospheric propagation, based on International Telecommunication Union (ITU) Recommendation ITU-R P.533-12.

The HF skywave model takes account of:

- Actual latitude and longitude of transmit and receive stations,
- Actual month, year and time of day,
- Antenna types at transmit and receive stations (whip, RF-1936, CODAN Code 463 etc.),
- Type of ground at transmit and receive stations (e.g. wet ground, dry ground, desert, sea),
- Height of the antennas,
- Transmit power and environment at the receiving station (e.g. city, residential, rural).

The inclusion of these factors, together with the time-varying nature of the modeled ionospheric propagation, allows the skywave model to bring to the synthetic training environment the realism of real-life tactical HF operations.

3. BENEFITS OF INCREASED FIDELITY

With research and development activities starting to provide more realistic, true-to-life radio simulation environments, one must turn attention to the potential application and benefits of such advancements.

3.1 Situational Awareness

The fidelity of communications modeling is not the only aspect of serious gaming that affects immersion and adds to the value of synthetic training. Most serious games invest heavily in realistic game sound effects from vehicle noise to weather, gunfire and explosive detonations. These stimuli not only draw the participant deeper into the training scenario, but also provide valuable experience in many of the difficulties faced trying to communicate in the theatre of operations.

Consider a simulated training scenario where a combat patrol in contact, radios their command to request quick response force support. Without provision for situational awareness, the player receiving the request will be unaware of any difficulty the transmitter might have hearing communications.

By adding this information to radio transmissions, both participants gain a deeper appreciation of the challenges of communicating in difficult, imperfect situations, the norm for real-world operations.

3.2 Electronic Warfare and Electronic Attack

Electronic warfare (EW) is an area that presents particular difficulties in training. Electronic warfare is the use of electromagnetic or directed energy to control the electromagnetic spectrum. The purpose is to either inhibit or jam an enemy's ability to use the EM spectrum to communicate or to prevent the interruption of friendly communications by the enemy.

The equipment required for this type of warfare is necessarily high-powered and broad spectrum. Its use in populated areas would compromise civilian communications (radio, television, Wi-Fi) and is therefore unfeasible.

The use of clear communications in training for electronic warfare clearly provides no knowledge or skills transfer in this area. With greater fidelity, it is possible to apply effects ranging from severe signal degradation, injection of artificial tones all the way to the complete termination of signal reception. Identification and rectification of the problem would therefore fall to the participants who would need to apply their skills and knowledge to restore communications. This is an example of where increased fidelity in communications simulation not only improves skills and knowledge transfer; it actually makes new areas of training possible.

3.3 Course of Action Alteration

One of the most compelling arguments in favour of increased communications fidelity is the impact it has on decision-making. With enhanced audio simulation able to deliver richer communications environments, the scope for training higher-order decision making skills also increases.

A commander who receives all information via clear communications is in an enviable but unrealistic position to make correct and appropriate decisions. Compare this to a commander who receives heavily degraded communications. The probability of flawed decision-making under pressure is greatly increased so preparing for this scenario is an important training objective at all command levels.

Whether applied in the context of command post training, casualty evacuation, fires, close air support or otherwise routine convoy operations, a direct line of communication between trainees can never be assumed. This adds to the immersion a player experiences, which as highlighted at the beginning of this paper, is a key aspect in supporting improved skills development and knowledge transfer.

4. NEXT STEPS

The development of games for the entertainment industry is one of the main driving factors in the advancement of serious games. Unfortunately, the area of communications simulation is not high on the list of their priorities. Considerable inroads are being made by a small number of innovative companies but much more can be done to realise the full potential of communications simulation.

4.1 Modeling Digital Systems

Calytrix's research and development efforts thus far have focused on degradation and effects for voice communications. For increasingly digital defence organizations, methods of communication have extended well beyond voice.

The sharing of tactical data such as event reports, imagery and intelligence is central to the goals of a connected Army, Navy and Air Force. As our dependence on this information increases, our exposure to the negative impacts of its degradation or loss also increases.

Modeling the effects of imperfect communications environments on data networks, and the impact on situational awareness that this can cause, is a key element in enabling the next level of training realism.

4.2 Complex Communications Environments

As the modeling of various communications methods improves, the way training exercise participants are required to interact with the various forms of simulated communications still remains somewhat cumbersome.

A participant's immersion in a training exercise is likely to be interrupted if the tools they are using require a number of steps to complete a simple action.

For example, when a trainee exits a vehicle in VBS they are required to manually switch their radio profile settings from the vehicle mounted, high power AN/PRC-117G to their individual AN/PRC-152 personal role radio. If serious games are to truly emulate real life, the choice of radio, radio mode or even plain vocal proximity communications (talking) should be simple or better still, automated.

The emphasis needs to move from simulating a particular communications device to simulating a complete communications platform. A *communications agent* would be aware of and react to an avatar's changing situation in a serious game. For example, it might react to the egress of a vehicle by automatically disabling the vehicle radio and enabling the personal role radio. If two players in the game were located within close range of each other, radio communications would be replaced by vocal proximity communications, which would alter the volume of otherwise clear-communications based on the distance between the players.

The immersion in training can be greatly increased when the trainee can forget they are using a tool and concentrate solely on the activity. This can only occur when the tools become so intuitive and fundamental that they become transparent.

4.3 After Action Review

After Action Review (AAR) is a central part of all training activities, allowing instructors and trainees to re-enforce instruction points and reflect on the execution of a training mission.

When employing the enhancements discussed in this paper, the communications for each trainee in the virtual battlefield are likely to differ and this presents a challenge for AAR.

The existing integration with systems such as VBS replays all communications in a clear, degradation free channel that is not representative of what the trainee would have experienced. This traditional approach needs to be enhanced to allow AAR to include an understanding of the communications context at the receiver. Such an enhancement however, would need to be carried out in a way that did not distract from the primary focus of the review.

5. CONCLUSION

Given the vast and numerous benefits in logistics, safety, adaptability and cost simulation brings to military training, all efforts should be made to ensure the maximum transfer of knowledge and skills is achieved. This fact is evident by the extent to which gaming graphics, physics and terrain production are continuously improving. Driven by the entertainment game industry, the importance of these parameters in increasing immersion is well understood. The buy-in experienced by players is created largely by fidelity and immersion and strongly correlates with the transfer of knowledge and skills.

The gap between the visual simulation of the virtual world and that of communications within it is both wide and avoidable. It is an area of training that is particularly suited to simulation, with a solid base of existing radio simulation tools. The application of these tools in a manner that couples them more tightly with the virtual environment helps deliver a richer, more immersive and realistic world, but more importantly, opens up new or enhanced training opportunities that simply did not exist prior.

Increasing the realism of simulation is a central goal of the serious games industry. One largely untouched frontier is that of communications simulation and this is a frontier well worth exploring.

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