Literature Review for the Simulation of Stressful Situations for Training Purposes

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Contents

1 Introduction

Every day, professionals all over the world are put into stressful situations in which they have to make decisions, often very quickly, which can have deadly consequences. Training for these scenarios is normally conducted by carrying out real life exercises. However, the flexibility of software-based simulations is unmatched and the call for its inclusion in training for stressful situations is very real.

The use of simulation, for the purposes of entertainment and training has been prevalent for hundreds of years Really?, with examples of software for simulation dating back to 1947 (https://patents.google.com/patent/US2455992) and documentation of simulated battles for training going as far back as at least 1824 (general von muffling), as well as examples for medical education going back to the late 1700s (https://www.ncbi.nlm.nih.gov/books/NBK559082/). The earliest potential example of an attempt at simulation for entertainment (discounting people role-playing in play) is a board game called Senet, dating back to 2620 BCE (https://journals.sagepub.com/doi/epub/10.1177/0307513319896288).

However, these scenarios are often generated by people, with a specific training goal in mind, which can impact the training scenario's utility in training personnel for organic/dynamic situations they may face for real in 'the field'. A potential solution to this is to provide AI-generated training scenarios, in which no one participant is aware of the parameters of the scenario, enabling them to focus entirely on solving evolving problems and completing dynamic tasks in the simulation. With the sudden rise in popularity of AI tools such as ChatGPT, many people and organisations now have an accessible route into the world of artificial intelligence and are now exploring ways to incorporate it into their metaphorical toolkit Talk about Amy's work.

One major limitation of the simulation of stressful scenarios is the disconnect between simulation and reality in terms of stress levels affecting the performance of the participant. For example, one may be able to defuse a bomb in a simulation 10 times out of 10. However, if you then put that participant in the same situation but for real, the fear of injury or death through detonation may cause the participant to behave differently, resulting in an unsafe procedure.

"Mario games teach us that even if something is essentially the same, psychologically it can be completely different. This example is very easy to understand." (https://twitter.com/Cheesemeister3k/status/1547440825420099586)

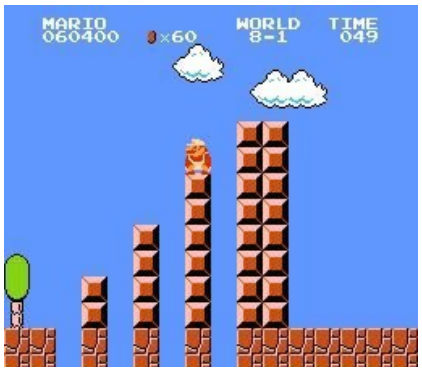

Figure 1: Caption for Image 1

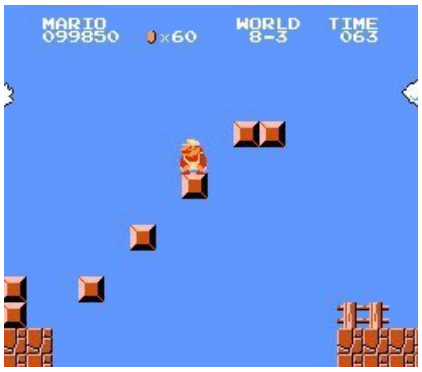

Figure 2: Caption for Image 2

1.1 Defining the Scope of this Research

The term simulation can refer to a range of topics. However, the scope of this research is on models generated by computer software.

1.2 Research Question(s?)

Generating AI-driven scenarios for realistic small-unit training scenarios.

Hypothesis

It is possible to produce a scenario in a simulated environment, in which self-preservation is paramount to the user, with the help of AI.

1.3 Defining Terms

Is it really stress?

Talk about walking into a building in an Arma 3 PVP vs commanding the team

"Next 15 seconds are decisive"

What about when you know you are going to lose? The feeling immediately goes away.

Fear of the unknown.

Does there need to be a win/lose scenario?

People when they die in game immediately get their phone out and go on TikTok or Youtube Shorts.

You want to try and outsmart your equals or superiors. Sneaking up on someone in a game or making them fall for it.

1.4 Types of Computer Software used in Simulation

Simulation 4.0 [**?**]

- Agent-based Modelling and Simulation (ABMS)
- Artificial Intelligence (AI)
- Augmented Reality (AR)
- Continuous Simulation
- Digital Twins (DT)
- Discrete Event Simulation (DES)
- Hybrid Simulation (HS)
- Petri Nets Simulation (PN)
- Virtual Commissioning (VC)
- Virtual Reality (VR)
- System Dynamics (SD)

1.5 Agent-based Modelling and Simulation (ABMS)

Agent-based modelling and simulation consists of modelling systems by making use of autonomous agents interacting with one another. [**?**]

1.6 Artificial Intelligence (AI)

Artificial intelligence is a simulation of a thinking being's capability to perform cognitive functions such as decision making, reasoning, seeing and communicating.

Talk about what this means in comparison to technology such as cassette-based car navigation. Use the clip from Tomorrow's World: https://www.bbc.co.uk/archive/cassette-based-navigation-1971/z6sbt39

"There is one drawback in all this, though, if for some reason or another the road system has been altered, there are roadworks or some diversion in force, which isn't programmed on the tape, well then this whole business just becomes one glorious guided mystery tour."

Is Google Maps AI?

Contrast this with the capabilities of Google Maps in which a diversion is handled well in almost every instance.

1.7 Augmented Reality (AR)

Augmented reality is a combination of real-world and computer-generated audio and visual, typically provided by software on a mobile device with a screen such as a smartphone, glasses or laptop. The user views the real world through the device's camera setup, with visuals laid over the image making them appear as if they were present in the real world.

1.8 Digital Twins (DT)

A digital twin can be defined as "a dynamic virtual representation of a physical object or system, usually across multiple stages of its lifecycle. It uses real-world data, simulation or machine learning models, combined with data analysis, to enable understanding, learning, and reasoning" [**?**]. Their use spans a wide range of disciplines including manufacturing, automotive, energy [**?**] and training applications for emergency services [**?**] and military personnel [**?**].

1.9 Continuous Simulation

- Vehicle modelling such as steering, breaking and accelerating

1.10 Discrete Event Simulation (DES)

Discrete Event Simulation (DES) provides a method for testing "what if?" scenarios by simulating the "behaviour and performance of a real-life process, facility or system". [https://www.ncbi.nlm.nih.gov/books/NBK293948/] DES provides a model by simulating a series of events. For example,

- Queueing Simulations such as plane boarding
- Livestock management

"It's this technique of mixing determinism and non-determinism, that makes DES so valuable" [1] (MATLAB YOUTUBE VIDEO)

1.11 Hybrid Simulation

Talk about sensory deprevation tanks and the possibility of using VR in combination with that

"If you were to overlay a virtual reality scenario into that situation you would have no stimulus to counteract what your eyes are seeing." Sam

2 Software-based Simulation of Stressful Situations

2.1 Introduction

When humans make decisions, this process can be impacted by factors such as oxygen levels [] and stress[].

2.2 Cyber Attacks

2.3 Diving

Talk about diving in Arma 3

Talk about how nice conditions can be dangerous because you can "forget" where you are

[1] https://www.oreilly.com/library/view/sql-in-a/9780596155322/ch04s01s01.html

2.4 Finance

2.4.1 Monte Carlo Simulation

2.5 Medicine

The field of medicine makes great use of simulation in areas such as training for surgery and estimating the impact of certain health conditions on society. Discrete Event Simulation provided means for estimating the societal cost of stroke FOOTNOTE cases in the UK for 2014/2015. [**?**]

2.6 Emergency Services

2.6.1 Firefighting with Aircraft

According to the Emergency Management Professionalisation Scheme of Australia and New Zealand, an Air Attack Supervisor (AAS) is an individual who is "responsible for for supervising aerial fire suppression activities and other tactical missions from the air". TODO:

A 2019 study found that virtual reality training exercises produce stress levels which are similar to those of a real exercise, when measured by heart rate variability (HRV). [**?**]

TODO: Talk about how this may be because AAS applicants are already experienced pilots.

2.6.2 Measuring Stress Levels of Participants in Simulated Scenarios

Data regarding the stress level of a participant can be taken by observing their heart rate, heart rate variability (HRV), how fast they are breathing, eye movement and chemical measurements. [**?**]

3 Simulation

3.1 Difference Between Simulation and Role-play

3.2 What is Military Simulation?

"This is not a game! This is training for war! I must recommend it to the whole Army." - General von Muffling, Prussian Staff Officer, 1824.

3.2.1 Combined Arms Tactical Trainer

3.3 What is it used for?

Military simulation/simulation of stressful scenarios are used for leisure, training and prediction of possible outcomes of real-life stressful scenarios.

This can be seen in entertainment with examples such as..., training with examples such as... and predictions with examples such as... .

3.4 How Accurate are (Military) Simulations?

Military simulation software is designed to accurately replicate real life performance of things (TODO: Thing? Really? That's the word you came up with?), such as the performance of weapon systems, vehicles and other technology commonly found in the battlespace (TODO: Define this as it's not an intuitive term).[2] Some simulators also go as far as to model the performance of humans in terms of physical performance, health and awareness (TODO: Expand on this).

However, a common experience from users is often that the majority of simulators that they play feel extremely realistic, yet perform differently when compared to each other. How can two simulators be realistic if they perform differently? (TODO: This is entirely my experience and some friends I know have said this. Maybe this is a research project to carry out?)

[2] Test here talk about battlespace

3.4.1 Destruction of Russian T-90 Proryv

On the 13th of January, 2024, the 47th Separate Mechanized Brigade of the Ukrainian Army reported the destruction of a Russian T-90 Proryv tank. TODO: [] While, as of 23/01/24, not all of the details have been confirmed about the engagement, it has been proven that the T-90's external systems (such as optics) were destroyed by the main cannon of a Bradley AFV, commanded by Serhiy of the Ukrainian Army. In an interview with SerhiyTODO:[], he stated that he knew which parts of the tank to fire at (to damage the external systems) as he had practised in "video games" (it is likely, although unconfirmed, that he is referring to War Thunder TODO:[]). The translation has been independently verified by Ukrainian speakers.

In War Thunder, engagements generally take place in which another player-controlled vehicle is also trying to destroy your vehicle.

3.4.2 Influence of Music while Driving test in Simulator

3.4.3 World of Warcraft Virus Outbreak

Between September 13th and October 8th 2005, players fighting a boss called Hakkar the Soulflayer could receive an in-game debuff to their characters which would spread to other characters if they were in close proximity. It was intended for this to remain only as a feature in the boss fight. However, an oversight allowed for this effect to be transferred outside in the "main" areas of the game, quickly causing this effect to spread through the characters like a virus.

Comparisons were made between the Corrupted Blood incident and how diseases spread in real life.

3.4.4 Top Gear Honda NSX Leguna Seca

"Fernando Alonzo arrived there saying "Well I know my around this brand new track because I've done it on an 'x-play-box-station' or whatever it was okay and I thought "that's odd". Can you really learn your way round a racetrack on a playstation thing?" - Jeremy Clarkson for Top Gear Series 7 Episode 6.

In this episode, Jeremy Clarkson completes a lab of the race track, Leguna Seca, in the racing software Grant Turismo 4, using a digital twin of the Honda NSX. His plan is to then try and repeat this attempt in real life at the real location with a real Honda NSX.

1'41.148 was his time on the Playstation.

"Piece of cake. But here's the thing. Could I now get round that track in that time in that car, for real?"

"This is the difference. Not sitting on a sofa [intelligible]. So that's the other thing you can do in the game is you can adjust your throttle and your breaks in the middle of a corner. You try doing that in real life, you're off. Off, wall, dead. Murder, blood, spurt, gush, artery, court-case."

2'01 was his time for real.

An on-circuit instructor helped Jeremy Clarkson to understand where the game was "true to life" and where it was "leading him astray".

"You don't get that on a Playstation, that surge of adrenaline."

When talking about attacking the "corkscrew" in real life in the same manner as he would in the game, Jeremy Clarkson stated that "the reality was just too daunting".

"So much you don't feel, that G-force that you get."

After his second attempt, 1'59.

On commenting that the brakes were "burning", Jeremy Clarkson states that it's "not me (him) that, it's the car's let me down".

"It's that part of your brain that makes you frightened. That's what racing drivers don't have... They're not thinking "what if a wheel falls off now." "What if I push the brake pedal and nothing happens"... "and that's what I'm thinking all the time".... "What if, what if, what if."".

1'57 the final time.

3.4.5 Treating Social Anxiety Disorder with VR

3.4.6 Training Taser with VR (AXON)

"It's a whole new level. You know, your heart rate gets pounding. You feel emotionally invested. You start sweating and you really feel that stress and that realism that you would in that situation"

"I have never seen the sort of intense demand that we're seeing for virtual reality training." - Rick Smith AXON CEO and Founder.

3.5 AI Adversarial Command and Control

TODO: Is the following even true or am I imagining it?

TODO: Write about how the AI knows everything but pretends it doesn't.

TODO: Write about developing AI which reacts to information which is only gathered the "Real way" through command and control

4 Computer Science Approaches to Improving Military Simulation

4.1 AI Command and Control through Decision Making

4.1.1 Individual Unit Approach

4.1.2 Alien Isolation's Alien

4.1.3 Mutually Supporting Units Approach

4.1.4 AI which can adhere to the Law of Armed Conflict

4.2 Immersive Scenarios

An immersive scenario is one in which the user/player/trainee is able to 'forget' that they are controlling a character in a virtual world; the less the user is immersed, the more aware they are of the reality of the situation.

Talk about those adverts where they deliberately play the game badly to make you want to take over, does this relate to people spectating in games

These are called Fail Ads

4.3 Necessary Features of an Immersive Scenario

4.3.1 Realistic Units

TODO: Look into whether realistic vehicles are necessary TODO: Look into whether people can tell different things apart. Can the average person on the

street tell a NATO tank apart from a Russian one? Are people's perspectives changed by WW2 films? Talk about when the girls at the beach thought that the WW2 re-enactors were recruiters and couldn't identify a uniform which was 80 years old.

TODO: According to a study which I completed called...

TODO: Source? Says who?

4.4 Audio and Visuals

Audio and visual work to confirm the content of each other to the observer [**?**].

4.4.1 Audio

4.4.2 Diegetic Sounds for Atmosphere

[**?**]

Wolfenstein: Enemy Territory

"The general consensus was that if you had a Thompson, it was slower but harder hitting and if you had an MP40 it was faster but it was waker." - 1

"Uhh the Thompson was sort of like this more boxy, smaller, it sort of had like a I dunno a sturdier kind of feel to it." - 2

"You'd use it until you couldn't then begrudgingly get the MP40" - 3

4.4.3 Visuals

"often identical and lack the same indications of individuality as the heroes' avatars"

Talk about how in games with enemies, often the most difficult fight and more meaningful fight is against the one who you know and have met. For example, generic bad guy number 1, who cares but talk about the boss fights in Grand Theft Auto or Star Wars.

4.5 Data Analysis for Performance Review

TODO:

- Add a source for how counter-battery is trained using radar

The nature of simulations is such that vast amounts of data can be collected and subsequently analysed in a way which isn't possible in real world scenarios. Although technology exists for collecting and analysing data in real-world scenarios, the sheer flexibility of simulated data is not yet matched.

For example, data regarding the source of indirect fire, such as artillery and mortars shells, can be collected and analysed by technology such as Radar, Field Artillery, No. 15 (Cymbeline). The purpose of this system is to determine the origin of the indirect fire, based on information sourced through determining the shell's velocity and trajectory. This information can then be relayed to friendly elements for use in the counter-battery role.

In the context of training for the counter-battery role as a field-gun crew in a live exercise, without simulation, a physical installation would be required to train on, including real projectiles being fired through the air and further real projectiles needing to be fired at the source to determine the effectiveness of the field-gun crew's performance.

With a military simulation, these actions can all be carried out virtually, with the ability to gather instant, qualitative and quantitative data on the performance of the crew, (providing the simulation was accurate).

5 AI Solutions to Problems with Training Effectiveness

6 Potential AI for those Solutions

6.1 Decision Trees

A decision tree is a "non-parametric supervised learning algorithm, which is utilised for both classification and regression tasks" (https://www.ibm.com/topics/decision-trees)

Parts of the decision tree can be turned on and off to further increase complexity and improve behaviour - Slides part 1 from CE811

6.2 Genetic Algorithms

Genetic Algorithms provided the solution for optimising the layout of a military operations centre, as explained by Wenbi Wang in hl"Layout optimization of a military operations center using a genetic algorithm".

This task consisted of the optimisation of the layout of a command centre for the Canadian Armed Forces, consisting of 68 staff (likely a mix of all ranks although these details are omitted).

Genetic algorithms could provide a solution for generating ideal "atmospherics" for immersive scenarios. For example, determining which weather, time and objective combination makes for the most immersive scenario.

6.3 Proximal Policy Optimisation

Proximal Policy Operation (PPO) is a reinforcement learning algorithm, which can be utilised for decision making in order for task completion. [**?**]

7 Metrics

7.0.1 Observing Short-term Stress Levels

Short-term stress levels can be observed through monitoring variable

8 Existing Studies

9 Potential Studies

10 Simulator Sickness

References

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