Distinguishing Games and Simulation Games from Simulators

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The advanced computational capabilities in modern personal computers have made it possible for consumers to experience simulations with a high degree of verisimilitude through simulation games (a.k.a. Sims). In recent years, the cross-boundary technology exchange between game and simulation technology, along with other factors, has contributed to the confusion as to what makes a simulation game and what makes a simulator. This article provides a user's and designer's perspective on a definitive comparison of the similarities and differences between games in general, simulation games, and simulators. It also introduces a method that can be easily used to distinguish games and simulation games from simulators by using observable design characteristics. On the other hand, the convergence of functionality and technology in simulation games and simulators has created new applications of simulation. One such application is in serious games. Serious games and simulation games are confusingly similar in many ways. However, they greatly differ in functionality. This article also provides a method to distinguish serious games from simulation games, to clarify the strict categorization between these two applications of simulation.

Categories and Subject Descriptors: K.8.0 **[Personal Computing]**: General – *Games*; I.6.3 **[Simulation and Modeling]**: Applications

General Terms: Design, Theory

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1. INTRODUCTION

In the past, the technology used in simulators was only available to high-end expensive industrial and military systems (i.e., "manned" training simulators [Hughes 1990]), since they made use of the extensive computational capabilities of high-performance computers (HPCs). Simulation technology was also used in non-real-time systems for running computationally intensive models of real-world systems (for example, analytic simulators [Hughes 1990] and weather simulation [Johnson et al. 1996]). Simulators and simulation applications were not available on commonly used personal computers (PCs), as the applications would normally require a number of days to run. The modern personal computer has made it possible to run simulators as well as other simulation applications on commodity personal computer hardware [Garrity 2005] because it is empowered with advanced computational capabilities, and at the same time is available at very low cost [Manojlovich et al. 2003]. This is evident in the hardware of the current generation of video game consoles (i.e., Sony's Playstation 2 [Sony 2005]; Microsoft's X-box

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[Microsoft 2005b]; and Nintendo's Gamecube [Nintendo 2005]); their performance surpasses that of minicomputers (e.g., the 1980 Digital Equipment Corporation's VAX systems [Dec 2005]) that are still being used in military simulators [Macedonia 2005].

The affordability of computer hardware capable of running computationally intensive applications such as simulations has made it possible to introduce a number of new applications for running simulations on PCs (e.g., the robotics simulator [Workspace 2005] and the electronics simulator [Workbench 2005]; another such application is called simulation games).

Over the past few years, as applications of computer simulation have gained acceptance in many commercial, industrial, and military areas, new applications have emerged. Modern technology has made it possible for commercial, industrial, and military simulation technology designed for high-end systems and for consumer simulation technology designed for PCs to both exist on similar operating platforms. This has led to the cross-boundary transfer of technology between the two areas. As a result, a number of hybrid simulation applications that integrate some of the high-fidelity simulation features of industrial systems have been created for PCs. These applications have been used for "serious" training purposes as well as for entertainment. Serious games [Seriousgames 2005b] are a result of applying simulation technology to non-entertainment (mostly training) purposes, while simulation games [Freedictionary 2005] are a result of applying simulation technology for entertainment purposes.

In recent years, as a result of this technology diffusion, simulation games, serious games, and training simulators have become popular. As simulation games improve in realism, the use of the technological elements of simulation games in simulators has increased, and has contributed to the technology exchange between simulation games and simulators. (The word "simulator" has been used in the titles of many simulation games (e.g., Codemasters [1990]; Microsoft [2005a]). And, in recent years, many simulation games have been used as simulators (e.g., Pandemic [2003] and Breakaway [2003]). These are some of the reasons that have contributed towards the confusion in distinguishing among games, simulation games, and simulators.

This article aims to resolve the confusion in identifying games, simulation games, and training simulators, and proposes a method to do so via features in these applications that can be observed by users and or operators. The article will then describe the areas in which hybrid applications of simulations such as serious games have successfully integrated the features of both commercial, industrial, and military simulation technology and consumer game technology. To prevent any further confusion in the emerging area of serious games, this article also provides a method to distinguish serious games from simulation games.

As this article attempts to bridge the highly theoretic field of game design and the historically technical field of simulation and modeling, a literature review of the terminology, key applications, categorization, and concepts in both fields is necessary. Sections 2, 3, and 4 provide a short yet adequately comprehensive literature review and introduce some of the significant characteristics of modern games, simulation games, and simulators relevant to the central thesis of this article.

2. COMPUTER GAMES

Formally, a game is best defined as a goal-directed and competitive activity that involves some form of conflict [Sauve et al. 2005], conducted within a framework of agreed rules [Lindley 2003]. The operator and or user of a game is referred to as the player or gamer. In games, the *player* or *gamer* is an individual or a group of individuals who are placed in a position where he (or they) has to assume the role of decision-maker in a game context [Sauve et al. 2005]. The *conflict* in games refers to the dynamic human- or computer-controlled obstacles that prevent the player from easily reaching his or her goal; the *obstacles* in a game provide challenges that are sufficiently intelligent to induce conflict in the form of reactions to the player's actions [Kasvi 2000]; the *challenges* in a game refer to the competition or struggle that arises when a player's action provokes an opponent's reaction [Kirriemur et al. 2004]; *cooperation* in games occurs when players team up to achieve a common goal.

Rules in games refer to a set of guidelines that describe relationships that exist between the player and the game environment. The guidelines specify the extent, nature, sequence, and causality of allowable player actions [Gray et al. 1998]. Game rules can be procedural, governing, or control rules [Stolovitch, et al. 1980]. *Procedural rules* describe the essential components of the game (i.e., player roles, allowable actions, number of players). *Governing rules* specify the end state of the game and the process that that must be performed to reach the end state (i.e., conditions for victory). *Control rules* define the model of action-consequence behavior for the game [Martin et al. 1998]. Rules can either be imposed explicitly on the players or be the result of an implicit agreement between players [Brougere 1999].

Traditional game-play requires the player to learn all the rules of the game before playing it. However, In the game-play mechanics of modern game-play this is not required [Wikipedia 2005]. Instead, it is only necessary to take a course of action that obeys the rules. Hence the rules in modern games tend to be carefully designed to implicitly develop the player's understanding of the governing and control rules in the game. As a result of the learning process in game-play, user patterns emerge over time, and depending on the nature of the game, these user-developed game-play patterns may or may not vary for different runs of the game. The pattern of interaction developed by the user is referred to as the *game-play gestalt* [Lindley 2003].

In other words, the game-play *gestalt* is what the player actually does within the system, limited by the rules of the game. Learning to play a game; making progress within a game; learning how to interact within the game system; and completing or winning a game are all part of the process the player goes through while developing and performing the *gestalt*. Technically, the *gestalt* is a particular way of thinking about the game-state from the player's perspective that involves repetitive perceptual, cognitive, and physical responses from the player [Lindley 2003].

The *goal* of a game refers to the predetermined end-state of the game and the notion of victory, winning, or reward associated with the end of the game [Salopek 1999]. It can include objectives that the player seeks to attain.

Because games are produced with the intention to maximize their sales and profits, the fundamental design objectives of games are trivial. In game design it is of paramount importance that a game is fun to play, as a fun game almost always sells well. In consumer-driven games the designer takes the audience's preferences into consideration when designing a game. In designer-driven games, a game will normally present an imaginative and coherent experience that agrees with the designer's vision [Rollings et al. 2003]. A game should ideally offer a continuous and intelligent challenge and a smooth, seamless experience. To create a successful game, the designer must understand the technology and the narrative elements. A game that sells well has to be attractive, so the designer must also think about the aesthetic style of the game [Rollings et al. 2003].

3. COMPUTER SIMULATION GAMES

Computer games are classified according to genre. Some common genres include action, strategy, adventure, role-playing, sports, simulations, and classic puzzle or board games [Oxland 2004]. Deyo et al. [1988] affirm that all games involve some form of simulation. This is very true, due to the fact that all game developers make considerable effort to recreate, to a high degree of verisimilitude, some aspect of the real-world. However, in contrast to other game genres, simulation games do not always involve a specific goal-oriented activity within the context of the game. Games such as *Sid Meier's Civilization 3* [Fraxis 2005] belong exclusively to the simulation game genre, as pursuing a goal-oriented activity is optional in the game.

Freedictionary [2005] defines simulation games as mixtures of games of skill, chance, and strategy that result in the simulation of a complex structure. Simulation games can be participatory, iterative, procedural, or situational in nature [Payne 2005].

In *participatory simulation* games, physical simulation places the player within the setting of the game itself. To make progress in the game, the player is then required to perform actions in the game under fictional circumstances. In digital games, examples include virtual reality and augmented reality game systems. *Dance Dance Revolution* [DDRFreak 2005] is a good example of a computer game that employs participatory simulation.

In *iterative simulation* games, the player is given the ability to create an end result such as a business model or a computer simulation module. This is done by plugging in known variables one at a time and observing the results of iterative changes. Game titles published by Lavamind [2005] are a good example of iterative simulation games.

In *procedural simulation* games, an action-consequence model is used to reenact a real-life process. Procedural simulation games are designed to train users to complete a process by following a well- documented set of procedures. Most training simulators fall into this category of simulation games.

Situational simulation games are built around a simulation model that mostly deals with the behaviors and/or emotions of people that relate closely to a group of circumstances. Recently, the definition of situational simulation games was extended to include human, computer, and non-playable characters. This was done to account for the application of advanced artificial intelligence systems in complex environments in games such as *The Sims 2* [ElectronicArts 2].

4. SIMULATORS

For the most part, the development of simulation technology began after the Second World War, when experts tried to find new applications for technologies developed for military purposes during the war. However, even in the late 1950s, computer simulation was not very useful because it both took too long and used too many skilled people to build and operate a functionally useful simulator. In the 1960s, however, this changed and simulation became a useful tool [Balachandran et al. 2000].

In the past, simulations were mainly used to study the behavior of a system as it changed with respect to time. A model of the system is designed before an actual simulator is developed. The model is usually modeled on a set of assumptions that are concerned with the operation of the system. The assumptions can be mathematical, logical, or symbolic relationships among the entities and or objects of interest [Banks et al. 1984]. The model is validated before it can be used to predict or reproduce the behavior of the system being modeled under varying sets of circumstances.

The study of simulation and modeling relates to the representation of time and state in a simulation model. On this basis, simulators are commonly classified by the simulation model that they adopt. A *Monte Carlo model*-based simulator makes use of state sequencing with no explicit representation of time. *Discrete event model*-based simulators specify state changes at discrete points in time. *Continuous simulation*-based simulators portray state changes as continuous over time. *Combined discrete event and continuous models* enable both techniques to be applied within the same simulator. *Hybrid simulation model*-based simulators generally incorporate an analytical submodel within a discrete event model [Shantikumar et al. 1983].

Simulators and simulation technology are used in many fields of science and engineering. Simulators are widely used for *system analysis* in management science and operations research to mimic behavior; to understand how to improve system performance; and to understand concepts. Simulation is also used in *education* to offer an environment that promotes the development of mental models in learners. Simulation is also used in modeling *acquisition and system acceptance* to answer questions related to whether a system meets a certain requirement and whether a subsystem contributes significantly to the improvement of larger system performance. Simulation is also used in *research* to recreate artificial environments to test system components or test the behaviors of an individual or groups, so that the results can be compared, contrasted, or categorized. Simulation in a military context can be used to support a number of mission types, including training, analysis, acquisition, mission rehearsal, and testing and evaluation. [Page et al. 1998]

Simulation is used to test the efficiency of models employed to explain or predict events in a system (e.g., weather simulation [Johnson et al. 1996]). Simulation is also applied to optimize the discovery of relationships between variables and to confront divergent approaches in order to perform a task that might otherwise be too difficult, too inefficient, or impossible in the real world (e.g., analytic simulators [Hughes 1990]; Milrad 2002]).

Most recently simulation is being used in *interactive entertainment.* In interactive entertainment simulation models are used in a real-time interactive mode to derive pleasure and enjoyment [Balachandran et al. 2000].

It can clearly be seen that the application of simulation covers a vast number of inter-related fields. Before proceeding to identify the differentiating characteristics between games and simulators, it is necessary to clearly identify the class of simulators being factored in the methods used for comparisons in the upcoming sections of this article. The next section will identify the essential characteristics of a class of simulators (training simulators) mentioned in the rest of this article.

5. TRAINING SIMULATORS

The class of simulators mentioned in this article are termed *training* simulators, which, in the context of this article, describe those simulators that embody the following characteristics.

1. Training simulators are designed to imitate the operations and behaviors of a facility or process, so as to develop the skills or experiences of the operators who use them.
2. The goal of the operator of the training simulator is to maximize his performance in achieving the task being simulated.

3. The motivation for developing the training simulator is to maximize the rates at which the skills of the operators are developed. Other reasons might include reducing the costs of training and reducing training time.
4. In training simulators, emphasis is placed on reproducing a real-world experience, with little emphasis on preserving the entertainment merits of the system.
5. Training simulators include those designed to evaluate, screen, and retrain existing operators.
6. Training simulators make use of graphically intensive virtual environments.
7. Extensive physical modeling is applied in the virtual environment to accurately reproduce the laws of physics in the environment.
8. Training simulation is performed in real-time.
9. The training simulator often makes use of custom input and visualization devices [Kang 2004].
10. Virtual reality technologies are often used to improve the immersiveness and interactivity of the training simulator [Bayarri et al. 1996].

Some examples of training simulators include, combat marksmanship simulators [Noptel 2005], flight simulators [L3 2005], and driving simulators [Bayarri et al. 1996].

6. DIFFERENTIATING GAMES, SIMULATION GAMES AND TRAINING SIMULATORS

The following section establishes an abstract distinction among games, simulation games, and simulators by building and assessing a common taxonomy based on the terms and concepts described in previous sections (the results are presented in Table I.

1. ***Involves simulation***. To use Table I successfully, the applications in question have to be identified as containing some simulation elements. In particular, a virtual environment that tries to recreate some form of fictitious or real-world environment is necessary. The simulation application also needs to interactively engage the player/operator in one of the four forms of simulation (i.e., participatory, iterative, procedural, or situational).

2. ***Imaginative experience***. An imaginative virtual experience may include experiences that have elements of fiction or fantasy, or an experience that simply deviates from reality. In the quest to provide interesting and exciting worlds, most games involve “unreal” fictional elements that contribute to an imaginative experience. Unlike simulators, there are simulation games that simulate the presence of fantasy worlds (e.g., *Master of Orion III* [Quicksilver 2005], *MechWarrior 4* [Microsoft 2005a]). But training simulators cannot use imaginative elements as an accurate representation of the real world. It is necessary to train operators to develop their skills in virtual environments in real-world situations. Thus the absence of imaginary experiences can be used to distinguish simulators from games and simulation games.

3. ***Entertaining, fun, and engaging***. An *entertaining* experience may be defined as an interesting or amusing one [Allwords 2005]. An *interesting* experience engages the attention of the player and provides excitement, and might also arouse curiosity or emotion [BrainyDictionary 2005]. The intent of games and simulation games is to engage players in a fun and entertaining experience, while the intent of simulators is to train and develop the skills of its operators. Regardless of whether an operator finds a training simulator entertaining, fun, or engaging, the fundamental motivation in creating a simulator should manifest itself via the mechanics that appear in a simulator operation. These mechanics can be entertaining, fun, and engaging features that are absent in the design of the simulator.

Table I. Identifying Simulation Games and Simulators

Identifying Characteristics		*Games*	*Simulation Games*	*Training Simulators*
1.	*Involves simulation*	1. A virtual environment is present. 2. The application interactively engages the user in a form of simulation.		
2.	*Imaginative experience*	1. May provide an imaginative or fictitious simulated environment.		1. Only provides recreations of real-world environments.
3.	*Entertaining, fun, and engaging*	1. Provides entertainment. 2. Provides interesting & engaging challenges. 3. Provides a fun experience.		1. Not intended to be entertaining, fun, or engaging. 2. Operator may possibly find the application entertaining, fun, and engaging.
4.	*Skills development*	1. Does not provide an application-specific skill development. 2. Possible, although not as a primary feature.		1. Operator skills-development is the primary purpose of a simulator.
5.	*Type of challenge*	1. Ideally, a continuous and intelligent challenge.		1. Challenges depicted accurately with respect to an equivalent real-world scenario.
6.	*Gestalt*	1. Presence of game-play patterns. 2. Game-play patters may vary. 3. Possible development of a game-play gestalt.		1. Presence of standard operational procedures. 2. Procedures do not change.
7.	*Goal-oriented*	1. Goal-oriented activity present. 2. End-state present.	2. No obvious end-state.	1. Goal-oriented activity absent. 2. No obvious end-state.

There are more than a few ways a game application can be made fun for the player. A taxonomy of fun in games was proposed by Leblanc [2000], which can be used to identify whether a simulation application has features that promote "fun." The taxonomy is defined as follows. *Sensation* is used to describe the user perception of "fun" when he or she receives a pleasurable experience while playing the game. *Fantasy* describes features that immerses the player in a fantasy world, and also a possible way to include "fun" in games. *Narrative*, or narration, engages a player in role-play in a story and also contributes to the fun factor in games. *Challenges* signify the presence of obstacles that users try to overcome as part of a game's fun activity. The ability to build social networks in a game is also considered a fun activity, and is associated with the term *fellowship*. The process of *discovery* engages the user in exploring uncharted territory and uncovering or discovering previously hidden functions as part of a fun activity. Games that allow players to freely express themselves are said to have implemented *expression* as a fun activity. Examples can be in the form of user-created "taunts" or fictional avatars. *Masochism* describes a form of fun that the user may experience if the game allows the user to submit his or her character to unnecessary death, violence, or socially inappropriate activity, and have a pleasurable sensation not normally possible in the real world. The taxonomy of "fun" describes eight distinguishable ways with which a user can judge whether a game activity is fun to play with. The absence of activities that suggest that a game is fun may mean that a simulation application is more of a simulator than a simulation game.

It is very likely that when two similar simulation applications, one a simulation game and the other a simulator, are compared side-by-side, the simulation game will contain more game mechanics that contribute to a fun and entertaining application. Hence this identifying characteristic can be used to distinguish games and simulation games from simulators.

4. ***Skills development***. The motivation for developing the training simulator is to maximize the rate at which operators develop their skills, while the operators' objective is to maximize their performance in the task being simulated. For games and simulation games, however, the entertainment features of an application are the highest priority. For these reasons, actual training simulators support high-fidelity simulations with a greater degree of verisimilitude, while games and simulation games only make a best effort at creating a representation that is consistent and accessible [Frauenfelder 2001]. If the operator's skill-development feature in a simulation application is not obvious, the presence of high-fidelity simulations can be used to distinguish a simulator from a simulation game.

5. ***Type of challenge***. Ideally, games and simulation games attempt to provide a continuous flow of intelligent challenges to engage the players. Lately, much research was done to introduce emergent challenges in games (i.e., the notion of a "good surprise") [Leblanc 2000] to eliminate lackluster challenges due to repetitive predefined content. However, introducing random, varying, unpredictable, or sometimes nondeterministic, content in simulators to create interesting and engaging challenges is undesirable and, in many cases, inappropriate. This is because the challenges in simulators have to be well-designed reproductions of real-world scenarios, so that an operator can develop useful skills, reproducible in real-life, without a simulator. The presence of random, unpredictable, varying, and non-deterministic challenges can then be used to identify games and simulation games.

6. ***Gestalt***. Section 2 of this article describes a game-play *gestalt* that is unique to games and simulation games. But for simulators this is an undesirable characteristic, as its presence encourage the operator to deviate from standard operating procedures in order to make progress at completing simulated tasks via actions that only work in a simulated virtual world. This is unacceptable, as the simulator can no longer guarantee that its operators are ready to perform real-world tasks after completing the simulation exercises. The absence of opportunities for operators to develop a game-play *gestalt* can contribute in identifying a simulation application as a simulator.

7. ***Goal-oriented***. Goal-oriented activities include any activity or set of activities that are conducive to achieving a desirable end-state in a game by a player. The end-state of a game is that associated with the notion "end of the game." It is achieved when an adequate number of victory conditions, as determined by the game, are met. There are a number of possible victory conditions. Here are some of the common ones: *Game-specific goals* are the most general, and refer to game-specific goals that are not usually duplicated in other games. An example is the checkmate move in a chess game. *Piece elimination* involves game-capture mechanics that make it necessary for players to eliminate a number of the opponents' playing pieces to meet the victory condition. To meet the victory condition in a *puzzle-guessing* game, its mechanics require the player to solve by logic a puzzle posed by the game. Games that make use of *races* as a victory condition reach an end-state when one of the players advances one or more tokens or

beyond a certain point in the game. *Structure-building* requires the player to acquire and assemble a set of game resources into either a predefined winning structure or one that is somehow better than those of opponents. In *territory control* games, victory conditions are met when a player gains control of the playing surface or gaining control of a specific piece of the playing surface [Wikipedia 2005].

A *victory points* system can also be used in place of victory conditions. Victory points are accumulated by a player over the course of a game. The winning player is either the first player to reach a set number of points or the one to acquire the most points at a predetermined finishing time or state of the game. Many games disguise victory points as game resources (i.e., money, gold, etc.) [Wikipedia 2005].

A simulation application can be identified as a game by the presence of (any) goal-oriented activity. The presence of goal-oriented activities can be identified by determining if any of the victory conditions (mechanics) of game-specific goals -- piece elimination, puzzle-guessing, races, structure- building, territory control, or victory points -- exist. Simulation games may possibly have some activities that allow victory conditions to be met; but successful completion of these activities and reaching the end-state of the game are optional. However, in training simulators, the goal-oriented activities mentioned here are not present, in addition to the absence of an obvious end-state [Semler 2004]. Instead, simulators might have activities centered on explicit scenario-based objectives. For example, in flight simulators the simulator will minimally require the operator to successfully take off from a runaway, navigate to waypoints, and land the plane.

Simulators might arguably make use of a number of different metrics collections and points systems to improve the skills of its operators in carrying out tasks that bear some similarity to some of the game mechanics used in games. However, when such skills-qualifying processes are in place, the fundamental purposes of these processes in games and training simulators differ greatly. To reiterate, the difference lies in the fact that the purpose of these processes in games is designed to be entertaining, fun, and engaging (Category 3, Table I), while the purpose of these processes in training simulators are designed to qualify and track the development of specific skills in its operators (Category 4, Table I).

To determine which category (i.e., game, simulation game, or a simulator) a simulation application belongs to, we will have to examine each identifying characteristic in Table I carefully, and decide for each characteristic which category the simulation application belongs to. After examining all eight characteristics a category for the simulation application can be selected by identifying whether a majority of identifying characteristics makes it belong to the categories of Game, Simulation Games or Simulators. In cases where an equal number of identifying characteristics have been assigned to more than one category, the assignment of identifying characteristics to categories will have to be revisited. It will help greatly, if the reasons for assigning identifying characteristics are recorded so that the process can be revisited easily when new features in the simulation application have been discovered at a later stage. Table I is a generalized subset of identifying characteristics that is effective in identifying most Games and Simulation Games. However, it only applies to Simulators that fall within the scope of Training Simulators, which is defined in *Section 5*. *Section 7* provides a case study on applying the method described here to determine if some simulation applications were Simulation Games or Simulators. That is then followed by the study of a specific genre of Simulation Games and Training Simulators, which led to the identification of more identifying characteristics that are unique to that particular genre.

7. DISTINGUISHING A SIMULATION GAME FROM A SIMULATOR

The method derived in Section 6 was used to identify the category two popular computer games, namely *Microsoft Flight Simulator 2004* and *The Sims 2*, belong to. The results are presented in Table II

Comparing the two popular games, namely *Microsoft Flight Simulator 2004* and *The Sims 2*, provides interesting results. We can see that a number of identifying characteristics in *The Sims 2* game eliminates it from the simulator category. *Microsoft Flight Simulator 2004* may be more of a simulator than a simulation game, mainly because a number of characteristics that would identify it as a simulation game are not there. However, its categorization as a simulator is arguable for a number of reasons, outlined as follows. The game accomplishes its objectives without the requirement that it provide skills development. Also, it has autopilot landing capabilities, a highly desired but as yet unachieved feature in real-life airplane operation.

Table II

	Identifying Characteristics	*The Sims 2*	*Microsoft Flight Simulator 2004*
1.	*Involves simulation*	1. A virtual environment is present in both applications	
		2. Type: Life/social simulation	2. Type: Flight simulation
2.	*Imaginative experience*	1.Provides an imaginative and fictitious simulated environment.	1. Provides a recreation of a real-world environment, accessible to planes.
3.	*Entertaining, fun, and engaging*	1. Provides entertainment. 2. Provides interesting & engaging challenges. 3. Provides a fun experience.	1. Not intended to be entertaining or fun. 2. Engaging for some players.
4.	*Skills development*	1. Does not provide any obvious application- specific skill development.	1. Pilots have been trained to fly planes using this product.
5.	*Type of challenge*	1. Engages the user in the continuous and intelligent challenge of satisfying the "needs and wants" of virtual characters.	Challenges depicted accurately with respect to flying a plane in real life, e.g., weather conditions.
6.	*Gestalt*	1. Presences of documented and reproducible game-play patterns. 2. Game-play patterns vary for each run of the game. 3. Players easily develop a game-play *gestal*t	1. Requires standard procedures to take off and land. 2. Procedures are standard for each plane.
7.	*Goal-oriented*	1. Goal-oriented activity present, i.e. , "wants and fears" system	1. Goal-oriented activity absent. 2. Game does not end.
		2. Game does not end.	
	Observation	This game is best identified as a simulation game.	This game has a large number of identifying characteristics that suggest it is a simulator.

The method proposed in Section 6 was used to study further the design of a particular genre of simulation games, namely *vehicle simulation games* and their counterparts, *vehicle training simulators*. Simulation games that involve vehicles to drive, fly, and steer boats are some of the most common forms in this genre. The games and simulators studied include *Gran Tourismo 4* [Eckberg 2005]; *Star Wars: Episode 1 Racer* [Lucasarts 2000]; *Racing Sims 3* [Ubisoft 2005]; *VR Driving Simulator* [Kang 2004]; and *VRAC Flight Simulator* [Menendez et al. 2001]. The following paragraphs describe the similarities and differences among vehicle simulation games and simulators.

The game and simulator have similar features, both attempted to recreate the "feel" of driving or flying a vehicle. This goal was achieved: a high degree of verisimilitude was simulated in operating the vehicle. The game and simulator both attempted to visually recreate virtual environments similar to reality. The vehicles in the simulation had gross performance characteristics (speed and manoeuvrability) similar to reality. However, they were also dissimilar in a number of ways; the areas in which differences exists, are detailed below:

Racing. There are primarily two types of racing simulations, namely *organized racing* and *imaginary racing*. Organized racing simulators try to reproduce the experience of driving a racing car or motorcycle in an existing racing class (e.g., Ubisoft's RS3 [Ubisoft 2005]). Imaginary racing games involve racing in imaginary situations such as those in virtual cities, countrysides, or fantasy environments [Lucasarts 2000]. Simulation games can include both organized and imaginary racing, while vehicle simulators, at best, support only organized racing.

Damage control. *Lightweight damage control* does not simulate any damage at all. On impact, vehicles obey rigid-body physics [Hecker 1998], and simply bounce off other surfaces or slow down. Other games and simulation games model damage as a single variable. When the accumulated effects of damages exceed a predefined threshold, the vehicle is then made to stop responding. A damage control model is considered (adequately) accurate when a vehicle is divided into areas of acceptable size to determine which areas have sustained localized damage from a collision. The extent of the damage is then assessed to determine the vehicle's performance. In vehicle simulators, however, damage control is modeled much more accurately. Constraint and penalty methods are often used to simulate the effects of crash impact from self-contact, node-to-surface impact, surface-to-surface impact, edge-to-edge impact, body-to-plane impact, body-to-body impact, tied interface with rupture impacts, meshed rigid-wall collisions, and specific airbag self-contact impact damages [Esi 2004]. Material validation laws are also normally modeled to simulate strain rate and damage effects [Esi 2004]. More importantly, high-fidelity vehicle simulators often simulate damage control independently of the model's mesh data, using either continuous or discrete connection methods to accurately model the object's deformation characteristics [Esi 2004].

Competition mode. Some simulation games can have competition modes in which the player can compete against other human or artificial players. Simulators, however, do not support competition modes.

Career mode. Some simulation games have game-play modes that require the player to follow the career-development process of their virtual character and acquire upgrades along the way to improve the vehicles. Simulators, however, do not support career modes.

Campaign mode. Some military flight-simulation games support campaign modes. In campaign modes, the game may possibly offer a series of missions, one at a time, in which the player must achieve a specified victory condition before going on to the next mission. Although, military training simulators involve training operators through a series of missions or campaigns; the campaign, mission, and management features are usually not implemented in the simulators.

Goals, game-play, and victory conditions. The common challenge in vehicle simulation games and simulators is to control and navigate the vehicle. Vehicle simulation games usually present the user with the primary goal of completing a race, mission, or level by achieving a preset number of victory conditions. Hence, vehicle simulators can be identified by the absence of goals and victory conditions.

Interface. However, in simulation games the control of the vehicles is highly abstract to reduce the learning curve in controlling the vehicle. But in simulators the verisimilitude of input is not compromised. A common abstraction that flight simulation games make is to coordinate flight movements automatically by coordinating the turning

Table III. Other Examples of Games and Simulation Games

Identifying Characteristics		*Steel Battalions*	*Microsoft Combat Fight Simulator 3*
1.	*Involves simulation*	1. There is a virtual environment in both applications.	
		1. Type: mech (giant robot) simulation.	2. Type: flight simulation
2.	*Imaginative experience*	1. Provides imaginative and fictitional simulated environment.	1. Provides a re-creation of a real-world environment accessible to planes.
3.	*Entertaining, fun, and engaging*	1. Provides entertainment. 2. Provides interesting and engaging challenges. 3. Provides a fun experience.	
4.	*Skills development*	1. Does not provide any practical application-specific skill development.	1. Unlike Microsoft Flight Simulator 2004, so far there are no reports that this game was used for training.
5.	*Type of challenge*	1. Engages the user in mission-based challenges. 2. Campaign choices are limited; a non-causal relationship exists between them.	1. Challenges depicted accurately re flying a plane in real life. 2. Challenges in choosing a user-determined path to progress in the game via campaign selection.
6.	*Gestalt*	1. Presence of documented and reproducible game-play patterns. 2. Game-play patterns vary for each run of the game. 3. Players easily develop a game-play *gestalt.*	1. Requires standard procedures to take off and land. 2. Game-play patterns vary with each plane. 3. Procedures are standard for each plane.
7.	*Goal-oriented*	1. Goal-oriented activity present. 2. The end-state is obvious when a number of missions are completed.	
		3. Goal-oriented activities represented by clearly defined missions.	3. The player strategically decides on the missions to achieve victory.
	Observation	This game is best identified as in the simulation genre.	This game is best identified as in the simulation genre.

movements of the ailerons and rudders. This is because most players have only one control mechanism, the joystick. In flight simulators, however, a number of custom input devices are put together to create a functional mock-up of an actual plane cockpit to avoid abstracting the interface so that the realism of controlling the vehicle can be maintained [Rollings et al. 2003].

These are some of the dissimilar design features among various simulation games and simulators we studied in the vehicle simulation genre. When the method in Section 6 is used to study other genres, more genre-specific distinguishing characteristics can be found. Table III shows an example of two popular games that can be identified as such due to the presence of a clear end-state in the game.

From Table III it can be observed that not all flight simulators can be classified as training simulators. It can also be seen that a majority of games labelled as simulation games fall into the games classification. This is true because many designers of simulation games realize the need to include a well-defined and achievable end-state (i.e., a quantifiable goal) to improve the appeal of the game. This is evident in *The Sims* series; both *The Sims* and *The Sims 2* retain their classification as simulation games. However, in *The Sims 2* the designers introduced a "Wants and Fears" system, an optional goal-oriented feature, to spread the appeal of the game to a wider audience. Some other games that can be identified as simulation games in the proposed taxonomy include Sid Meier's *Civilization* series and a number of others in the Maxis Sim series (i.e., *SimCity, SimEarth*, etc.).

The next few sections will introduce some of the latest trends in design that will increase the difficulty in distinguishing games and simulation games from simulators.

8. THE CONVERGING TREND OF SIMULATION GAMES AND SIMULATORS

Both simulation games and simulators share a common set of enabling technologies. Thus it benefits both communities to leverage each other's innovative solutions, and thus improve both [Zyda et al. 1997]. The increasing array of features provided by commercial game engines has enabled the game industry to produce titles that have begun to rival the high-fidelity simulation environments found in military simulators.

Because computer game technology is cost-effective, it is now being used in various armed-forces simulators. The level of realism provided by these simulators is adequate to motivate and engage a game-savvy generation of soldiers. In 1995, the U.S. Marine Corps used the commercial version of *Doom* to development *Marine Doom* to improve the teamwork and coordination of soldier teams. Fully 3D games have made it possible to use these simulation games for military purposes. *America's Army* [Zyda et al. 2003], a fully 3D game that started out as a recruitment tool, is now used to train future military officers. Another game, *Full Spectrum Warrior* [Pandemic 2003] is designed to train squad leaders in real-life urban warfare combat tactics. There are also several COTS (commercial off-the- shelf) games such as *Delta Force 2* [Novalogic 1999]; *Steel Beasts* [Esimgames 2004]; and *Falcon 4.0* [F4hq 1998] adapted by various armed forces to enhance the games' relevance to military training [Fong 2004].

High-resolution, real-time computer graphics are no longer confined to expensive and proprietary computer systems. In many instances, cheap personal computers not only have rival proprietary set-ups, but in some ways have surpassed them [Lewis et al. 2002]. For that matter, in many cases the visualization systems used by present-day games provide sufficient performance and realism for simulators. One such case is the UTSAF [Manojlovich et al. 2003] project, which performs 3D visualization using an inexpensive Unreal Tournament [Epic 2005] game engine, to perform its visualization.

The fundamental design objectives for simulation games and simulators influence the design of supporting technologies for simulation applications. These differences prevent the convergence of game and simulator technologies; but they do not prevent the emergence of hybrid simulators that do not require, in certain functional portions of the system, as much accuracy as traditional simulators do. For example, a military strategic mission-planning simulator that gives a top-down view of the operational theater does not require an accurate visualization system [Manojlovich et al. 2003]. The latest games have, to some significant extent, incorporated technologies exclusive to simulators: for example, discrete-event simulation was incorporated (in part) in the newer game engines [Garcia et al. 2004].

The similarities among simulation games and simulators due to the fusion of technologies are a major contributing factor to the confusion in differentiating the two applications of simulation. Although the method presented in Section 6 is useful in studying and identifying design characteristics in simulation games and simulators that differentiate the two applications, it is still necessary to revisit and update the results of the study to account for changes in design trends due to the converging trend of these two applications over time.

The next section will introduce the class of *serious games*, which in many cases uses game and simulator technology primarily for nonentertainment and largely for skills development. The converging trend of simulation games and simulators is demonstrated well in many implementations of serious games.

9. SERIOUS GAMES

Serious games refer to "applications of interactive technology that extend far beyond the traditional video-game market, including: training, policy exploration, analytics, visualization, simulation, education, and health and therapy." [Seriousgames 2005b] The serious games initiative grew out of an interest in the use of interactive and immersive technologies in training and education [Seriousgames 2005a]. Since its inception, the initiative has created an emerging market for the application of gaming technologies, and in many cases, simulator technologies [Raybourn 2005].

Game technologies are currently used for simulators that require faithful maintenance of game objects only (i.e., player, object, and terrain information). In such applications, the accuracy of game engines is deemed completely adequate. Even in simulators that require the precision that only high- fidelity simulation technology can provide, game technologies have demonstrated that they can add value by providing maintenance functions for the manipulation of 3D data, networking, and synchronization, or by driving high-fidelity hardware accelerated graphics [Lewis et al. 2002].

A number of serious games were used for tactical simulators that used game technologies, and were highlighted in Section 8 (i.e., *America's Army* [Zyda et al. 2003]). An extensive list can be found at Socialimpact [2005]. Since serious games are primarily built on game technology and most serious games attempt to provide some form of simulation for non-entertainment purposes, an attempt to distinguish serious games from simulation games was made. Table IV presents the results of the attempt. It was found that the main difference between a Simulation Game and Serious Game lies in the fact that most Serious Games are developed for some form of skills development. Differences exist also because of the fact that Serious Games are built for non-entertainment purposes

Table IV. Identifying Simulation Games and Serious Games

Identifying Characteristics		Simulation Games	Serious Games
1.	*Involves simulation*	1. A virtual environment is present. 2. The application interactively engages the user in a form of simulation.	
2.	*Imaginative experience*	1. May provide an imaginative or fictitious simulated environment.	
3.	*Entertaining, fun, and engaging*	1. Provides entertainment. 2. Provides interesting and engaging challenges. 3. Provides a fun experience.	1. Built for non-entertainment 2. Can provide interesting and engaging challenges. 3. Can provide a fun experience.
4.	*Skills development*	1. Does not provide an application-specific skill development. 2. Possible, although not as a primary feature.	1. Usually designed to provide some form of skill development, especially in training applications.
5.	*Type of challenge*	1. Ideally, a continuous and intelligent challenge.	1. The challenges vary with the type of simulation.
6.	*Gestalt*	1. Presence of game-play patterns. 2. Game-play patterns may vary. 3. Possible development of a game-play *gestalt.*	1. Presence of game-play patterns and *gestalt* vary, depending on the application.
7.	*Goal-oriented*	1. Goal-oriented activity present.	
		2. No obvious end-state.	2. May or may not have an obvious end-state, depending on application.

while Simulation Games are built for entertainment purposes. It is difficult to apply the other identifying characteristics to identify Serious Games, as

Serious Games can already been found in diverse areas of applications for a number of different purposes, other than just training, simulation and entertainment. The uses of Games for non-entertainment and simulation purposes are a recent phenomenon. It is highly likely that this phenomenon will carry on way into the future due to the competitive benefits that game technology offers over simulation technology.

10. CONCLUSION

The transfer of technology between Simulation Games and Simulators has indeed made it difficult to distinguish Games and Simulation Games from Simulators. This paper has provided a method to distinguish Games and Simulation Games from Simulators based on observed design characteristics from the users' perspective, as well as relevant examples on how to do so. The distinguishing characteristics can also be used to categorize hybrid applications of simulation or game technology as Games, as Simulation Games or as Simulators. This paper is highly relevant, when considering the converging trend of game and simulator, design and technology. Already, the emergence of Serious Games has created a cause for concern regarding the increasing confusion of the types of simulation applications available. This paper also shows how the method outlined here can easily be extended to accommodate other hybrid applications of simulations, such as Serious Games. The similarities and differences in design characteristics presented here, when considered carefully can be used to successfully categorize Games, Simulation Games, Serious Games and Simulators.

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