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Chapter 24

Gaming with Purpose: Heuristic Understanding of Ubiquitous Game Development and Design for Human Computation

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Abstract

The emerging growth of digital gaming has resulted in wide audiences of players. These players are capable of solving difficult problems through human computation games while ubiquitous gaming provides play anywhere opportunities to solve those problems. This chapter outlines characteristics of human computation games and ubiquitous games in a variety of disciplines, describing they key components of such solutions and articulating their distinguishing characteristics from other types of entertainment software. The focus is on entertainment software design theory as applied to human computation games. It outlines the fundamental characteristics of such games and offers approaches to applying human computation games to promote player engagement and adopt application. Readers will learn how ubiquitous gaming and human computation can be combined to address the simplest educational goals through the most complicated problems in the sciences. A brief structural analysis of

human computation games is provided. It concludes with a discussion of the potential of persuasive play and the rhetoric of gameplay in the coupling of human computation games with ubiquitous gaming.

Introduction

Play is at once one of the most valuable elements of the human experience and one of the least appreciated. In the everyday practice of working, the work of problem solving and solution finding is often diametrically opposed to the connotations of play [1]. Save for a few playful enterprises such as professional sports or artistic performance, work is not play, nor is play work. Psychologists have demonstrated the value of play in a variety of developmental milestones and fundamental brain functions [2].

However, play and the formal organization of play into games is emerging as a work practice capable of solving very complicated problems. This change is largely supported by the confluence of a few basic elements. Culturally, there has been an increase in digital game interest among wide audiences of players [3]. Games are not merely the experience of childhood. Games are also a kind of work in themselves, involving substantial time commitments and energy [4] by players.

Professionally, the types of human work have evolved. As the workforce matriculates through another shift from information technology to automation and higher order artificial intelligence systems [5] the definition of skilled labor changes. In technology, the growth of ubiquitous computing and the increased use of human computation games creates a possibility space for games that convert the serious business of work into the seriously engaging experience of play.

Ubiquitous computing defines an increased permeation of computing processers into the everyday experience. Evolving from the traditional desktop model, in which a user actively engages in computing experiences through a distinct start and stop session, ubiquitous computing integrates those computer sessions into everyday experiences. The simplest examples of ubiquitous computing employ the colloquial notion of an internet of things [6]. Small independent devices with networked computing capabilities communicate with each other exchanging relevant data. A coffee maker might update a smart phone app to indicate a need for new filters or a home thermostat might adjust ambient temperature based on the number of inhabitants in the home to make rooms cooler during a party and warmer when only one person is home. Basic ubiquitous computing examples exist in the commercial marketplace and include the Nike+ system [7] and host of other self surveillance technologies [8]. Human computation games, on the other hand, are the logical conclusion of a very simple line of thought. First, as evidenced by consumer demand and variety of psychological studies, people like to play computer games. Second, people spend a lot of time and cognitive energy playing computer games. Third, that game-playing cognitive energy could be dually employed to not only entertain players but also to solve complex problems. Human computation games, or HCG, have witnessed a significant growth in the last few years [9]. The remainder of this chapter is organized into five basic sections. The first outlines the defining characteristics of human computation games. The second outlines the design concept of the human cloud for human computation games. The third provides an overview of design patterns in these games based on heuristic analysis. The fourth is a succinct structural analysis of HCG. The chapter concludes with design models for creating ubiquitous and persuasive play using HCG.

1. Defining Characteristics

Human Computation Games as Productive Play

The basic concept behind HCG is to transfer players' energies in entertainment gaming toward productive play. Productive play is defined as play experiences that yield a non-game benefit. A game offers productive play if it results in the extrinsic production of materials, resources or processes of value outside of the game world. In scientific communities for example, productive play focuses on games that make new data. The evolution toward productive play in entertainment is somewhat akin to the evolution of energy storing technologies. Just as the energy produced from a car's brake system can now be stored for later use in electrically powered accessories, play can serve as both necessary human release and extrinsic problem solver.

HCGs and other types of productive play fall under the greater domain of games with a purpose (Gwap) [10] and the general but contested term serious games. Such games reverse the original notion of asking games to teach players, and instead often afford players the ability to teach computers. This model of play defines the foundation of historical human computation gaming. In their brief but expanding history, such games typically apply elements of game design (e.g. competition or construction) to resolve non-game problems. A typical play systems like ESP [11] endeavors to add a light play structure to the monotonous task of identifying images. The goal is to convert a monotonous task into something more engaging.

There are currently more than 40 human computation games produced and released. For clarity we have clustered these by their goal, and secondarily by the specific problem they address. The existing human computation games general fall into one of 5 master domains. The games may intend to enhance and collect descriptive data, improve results, collect data, assist existing systems or simply compute new solutions. Although these goal are not mutually exclusive, the help to understand how the games are aligned. Within each of these goals, the games also have particular types of problem. The goals and problems are outlined in table 1 as follows:

1. Enhancing and Collecting Descriptive Data	
Annotating images: Collecting descriptive data for images	
	ESP Game [11], Phetch [12] , Photoslap [13], Application for Semi-Automatic Annotation[14]
Annotating music: Collecting descriptive data for images	
	Tagatune [15], Herd it [16], Moodswings [17,18]
2. Improving Result and Result Sets	
Improving CAPTCHAs:	
	Magic Bullet [25]
Improving search engines	
	SearchWar[19],Intentions [20], Learning Consensus Opinion [21], Thumbs Up [22], Page Hunt [23], Karaoke Callout [24]
3.Collecting Data	
Collecting common sense facts:	
	Verbosity [26], Virtual Pet and Rapport Game [27], Common Consensus [28], 20 Questions [29]
	Producing useful geospatial data:
	Eye Spy [30] , GeoTicTacToe and CityPoker [31], City Explorer [32]
4.Assisting Existing Systems	
	Assisting language processing tasks:
	Phrase Detectives [33] , PlayCoref[34] , WordSense [35], Sentence Recall Game[36]
	Assisting the semantic web:
	On-to Galaxy [37], Onto Game [38]
5.Computing a Solution	
	Predicting protein structures:
	Foldit [39][40]
	Solving computationally difficult problems:
	Pebble It [9], FunSAT [41], Virtuoso[42]
6.Solving a variety of general problems:	
	Callabio [43]. 1001 Paraphrases [44], Outrandom [45], Audio Puzzler [46], The Dogear Game [47]

Table 1. Grouping HCG Solutions by Goal and Problem

The fundamental benefit of digital computing power is that computers excel at tasks deemed monotonous by humans. The basic challenge of employing human computation is that humans tire quickly in monotonous tasks. Yet, if constructed improperly any task can decline to monotony. This is where the art of game design becomes essential. The responsibility of a game designer is to understand what keeps a player engaged by balancing the challenges in games to the player's abilities. When this balance is achieved it produces the much sought after flow state [48]. The flow state is a peak state, where players excel at their play activity and demonstrate exceptional focus. This focus is important, as it heightens the players propensity to sharply solve complicated problems [48].

Digital entertainment games have more than a 30 year history of combating monotony. Algorithmic play, or play designed around the execution of a sparse game action set with mathematically managed changes in challenge is a hallmark of early entertainment computer games. Computer games in the late 1970's and early 1980s typically asked players to matriculate through a set of repeated tasks which merely varied by speed or agility. The concept is again fundamentally basic. If the player has managed to eliminate 10 enemies in 30 seconds, give the player another round with 15 enemies, then 20, then 40, and so on. This type of play can support engagement, because the monotony is balanced by increased challenge. Expert players are rewarded with increasing challenge, improved efficacy and positive feedback (i.e. high score), while novice players are supported with easier play and simpler interactions. Structurally, game design has borrowed much of its success from practiced execution of multidisciplinary theory. Modern games employ computer science, psychology, education, aesthetic study, storytelling and more to accomplish their goal of engagement. Modern games are designed around matriculation schedules that allow players to develop skills while a system evaluates their success. They are designed to invite players and keep them. They exist in a crowded and competitive space, where consumer allegiance lasts only as long as the experience is satisfying. As result, games have evolved quickly in this very competitive environment.

Importantly, modern computer games for entertainment are often a collection of complex problems that offer a healthy balance of challenge and cognitive accessibility [49]. They offer a wide variety of play experiences and have developed distinct cultural languages and interaction standards. As such, the population of game players in the world has increased significantly through the years [50]. Supported by the growth in low cost computing resources like smart phones, portable gaming consoles and tablet computers, game players span a wide demographic. They include preschoolers through senior citizens, the illiterate through the highly educated, and an even wider array of domain experts [50].

In contrast, games designed for productive play have not garnered the same success or wide adoption. The most successful games in this domain are a mere fraction of the entire digital game domain. In 2011, more than 240 million video and computer games were sold[3]. FoldIt [39], one of the most significant and productive applications of this technology, has been estimated to have just over 60,000 players in total, based on public data provided on the FoldIt site [51]. In the entertainment domain, games such as Team Fortress 2 continue to have more than 75,000 players a day [52]. This tremendous disparity could be understood as a negative reflection on the state of productive play games. Instead, we understand it to be an extraordinarily untapped resource. Much like discovering there are billions of gallons of untapped oil below your feet, the potential to employ the enormous population of gamers seems to bode well for designers of productive play and human computational games.

All of the aforementioned HCG research projects have demonstrated evident potential in employing digital gamers as problem solvers. The challenge for developers of such games has moved to how to make effective human computation games. The remainder of this chapter combines observations from successful human computation games to illuminate the practice of designing, developing and deploying these games. These observations are derived from demonstrated examples of effective design theory with the practicalities of employing large sets of people through human computation gaming.

2.The Benefits of a Human Cloud

Understanding The Human Cloud

One basic way to succeed in the domain of human computation games is to understand players as a computational resource. The incredible ability of the human brain to solve complex problems or to creatively re-conceptualize a problem offers a unique opportunity to extend computing resources. The success of Internet crowdsourcing and allied approaches demonstrates that the technology can facilitate collaborative problem solving across widely disparate geographic spaces and knowledge domains [53]. Theoretically, crowdsourced solutions can employ Condorcet's Jury Theorem [54] which states that for a majority decision, if the probability of individuals making the right decision is greater than 1/2 then as the group size grows the probability of the group making the right decision approaches 1.

Under technological model of crowdsourcing, people serve as the ultimate processing resource in a chain of technologies that merely facilitate their success. The technology forms the infrastructure, handling communication and collaboration while assisting analysis. The unique character of crowd analyzed problems is beyond the scope of this chapter, but both Sunstein [55] and Surowiecki [56] explain it thoroughly. In short, if the human player is an untapped resource, it is one with great and diverse potentials. It is the designer's responsibility to understand how to best refine that energy resource while accepting its unique characteristics. These characteristics include a diverse set of interests and priorities. They involve integrating and supporting an array of intermingled preferences for engagement strategies, work and play styles [55].

If the precedent of crowdsourcing is applied to the design of play experiences the persistence and cost of resulting solutions should diminish. Where crowsdsourced solutions ask players to solve problems as part of work, human computation games ask players to play through them. The difference in focus and commitment is appreciable compelling when the experience offers a flow state. Importantly, people seek the work of play. Players pay money for the experience of games and look forward to their diversions. Unsurprisingly, work does not elicit the same response.

If players can be utilized as problem solvers through play, they become productive nodes in a large network of solution producers. We describe this conceptual network as the human cloud. The human cloud contains multiple nodes each processing some basic problems asynchronously or synchronously. The aggregate sum of their solutions is often worth more than the single contribution of one individual. It is a resource whose power stems from aggregate energy.

To tap this energy a couple of basic approaches have been made in traditional HCG. The first is to employ large sets of game players to solve the same problem. Players may compete to solve this problem fastest or best. They may be asked to solve the same problem multiple ways or to refine another player's solution. Solutions may be reprocessed and submitted back to the player group for continued processing and refinement.

Under this model the system is typically setup as an extended client-server architecture. The player is provided a client with a subset of the problem presented as a game. The player completes the problem and their result is encoded and shipped to a master processor (i.e. typically a computer server) to be logged. A traditional client-server software model is used, as is common to network systems. Accordingly, the player is presented a puzzle or game conflict as play, they solve the problem and send the process through which they solved the problem to the master processor. If the system affords it, the player may be provided another persons' problem solution to refine or they may be provided with an entirely new problem upon completion. We define this first model as "iterative computational resourcing".

The second model employs sets of players not as computational resources, but as domain experts. Instead of understanding the human brain as a computer for solving complex problems ill-fitted for digital logic boards, the human brain is understood as an analytic processing machine akin to online analytic processing software [57]. In this model, the player is asked to interpret based on its wide, disparate and seemingly disconnected knowledge stores. In this model, humans can answer the surprisingly challenging question, what is wrong with this picture. Under this second model, players may also be used as field researchers, collecting data for processing by others. More interestingly, games in this domain may ask players to identify criminal activity or find representational issues by interpreting visual data [11].

The second model employs the complex system of deductive reasoning or situational awareness stored through years of human experience. In short, humans are very effective at heuristic problem solving. The human brain immediately understands, for example, when a depicted plant is artificial or real. It does so by combining the complex and innate cues of aesthetic properties (e.g. light reflection, shadow, etc) with the experience of the everyday. This second model is very much about training computers to understand what humans do. It is no surprise that this model is much like the inverted classroom practiced in non-traditional education. Players of these games may be domain experts, or they may simply be capable of proposing hypothesis they can test.

As an example, the work of this second model is common in the computer science of simulation for computer graphics. In evaluating the results of a 3D computer graphics renderer, the human evaluator provides the computer with data about what makes the system more accurate. The human analyzing the results produced by the computer is merely using the everyday experience of human perception. One render might result in artificially high luminosity. Another might be computationally inaccurate, but perceptually perfect. This type of human-computer interaction is part of the daily experience of some computer sciences. Such work occurs in everything from digital language processing to artificial intelligence modeling. We call this model "iterative observational resourcing."

Human computation games can afford wide scale polling without the tedium of simple diagnosis. Computer game players use the term "grinding" to refer to repetitive in game tasks in games. As an example of grinding, players might grind through the relatively simple task of killing boars in a mystical adventure to earn points for more exciting activities. The boars are analogically similar to lichert scales and multiple choice questions in a poll. However, the sharp distinction is that many players seek the experience of a game, where they do not often seek the work of polls.

In both models, the challenges of sustained engagement persist. It is not enough to ask players to compete in identifying elements in an image, for example. Such a game is bereft of play elements that excite multiple play sensibilities. Players who seek creative play or community play would be ill fitted for such a game. As general game design has learned, effective play is about the affect of multiple play sensibilities [2].

3.Design Patterns

Designing Human Computational Games

There are two dichotomous solutions to the design of HCG. The first is to determine the problem to be solved then apply an appropriate game design to it. This is a problem determinant approach. The player experience is determined by the problem. Typically for problem determinist approaches the game is a thinly veiled extension of the problem. The early successes FoldIt and the ESP Game stand as clear examples of this approach.

The second solution is to reverse engineer the game solution by starting with a game. This is the game determinant approach. Beginning with common game mechanics and types, such as first person shooter or driving simulation, designers can evaluate the mechanics and apply problems to them. Starting with the game first allows the designer to rely on established game mechanics, reducing the player's learning curve. It also simplifies the design process by providing a template for an engaging game experience. Of course, this is an atypical solution for one practical reason. Most practitioners of HCG are using HCG to solve their specific problem. They are not looking for a problem; they are looking for a solution.

However, as the world of HCG expands, this practice becomes more practical. To start, many games have varied gameplay mechanics. These mechanics may be the filler that links two sections of the core game mechanics, such as driving from one puzzle to the next. It is at this stage in the design that the game first approach can be applied. Perhaps the driving mechanics can act as a filter. The secondary game mechanics for driving could be used to select order, by asking players to avoid as many road obstacles as possible. When they hit an obstacle, that obstacle selects the puzzle they must solve. Across multiple players the driving mechanic becomes a semi-random selection scheme which is fun to play but also useful to the researcher.

The third approach hybridizes the aforementioned solutions. This is design by analogy. The HCG designer identifies their problem and sorts through existing game mechanics for the most similar existing game mechanic. Identifying spam becomes shooting enemy space ships. Sorting gene pairs becomes a puzzle matching game. This approach is growing in popularity as evidenced by games like Magic Bullet [25].

Regardless of the ways in which the general concept of an HCG is designed, the fundamentals of game design persist. Not all HCG uses are actually games. Instead they are play. Play can be unstructured, while play is structured play. In teaching game design for a decade, the disction between play and games are somewhat difficult for students to understand. To clarify this distinction, the author outlines a

5 element model for communicating the key elements of a game. If a play system fails to have one of these 5 elements, it fails to be a game and remains only play. They are useful in formally discerning play from games:

Competition:

Competition is the goal in the game. The competition might be to accrue more points than your opponent do or to save something before a specific amount of time. Competition does not require opponents, but it does require a goal and a perceptible distance from that goal.

Implements:

Implements are what players use to eliminate obstructions to their goal. In traditional games, implements are the weapons, vehicles, spells and related tools used to meet the goal. In HCG these elements are typically analogical or literal representations of the computational problem.

Territory:

The physical or theoretical parameters of the game. Territory includes any boundaries in a game, but conceptually applies to all limitations. In a game, territory dictates not only where a player can jump, but how high.

Inventory:

Inventory defines the items players accumulate during play. Inventory elements typically include points that are apparent to players or hidden from players but used for matriculation and calculation).

Rules:

Rules dictate how the four prior elements must be used with the game. Rules establish the relationship between competition, implements, territory and inventory.

Effective conceptualization of an HCG through problem-determinant, game determinant or hybridized approaches are an appropriate place to start. Deconstructing the proposed design into the five elements of game design will reveal apparent design flaws. It is also practical to create a game design and media design document outlining the design, technical and artistic needs of the proposed game design. A game carefully executed through these steps will be complete. These steps however do not address the fundamentally important question of how to create engaging HCG experiences.

Using Isomorphs

To resolve the challenge of keeping players engaged, we suggest the application of isomorphs. Isomorphs re-imagine a real world problem into a computer game. Formally, an isomorphic problem has multiple presentation formats at the surface level, but is the same problem underneath. Isomorphic problems have been of interest to cognitive psychologists, and they havebeen used to help researchers understand strategic approaches people take to solving problems [58]. An isomorphed problem example that illustrates the basic concept is for tic-tac-toe. Zhang et. al. [59] show some common ways of presenting tic-tac-toe, and we have replicated one of these in Figure 1. In Figure 1, the number game is shown where players take turns at picking a number (by coloring in a circle) with the goal of picking three numbers to total fifteen exactly. This game is the same as tic-tac-toe, and the figure shows how these numbers can map to locations on the tic-tac-toe board.

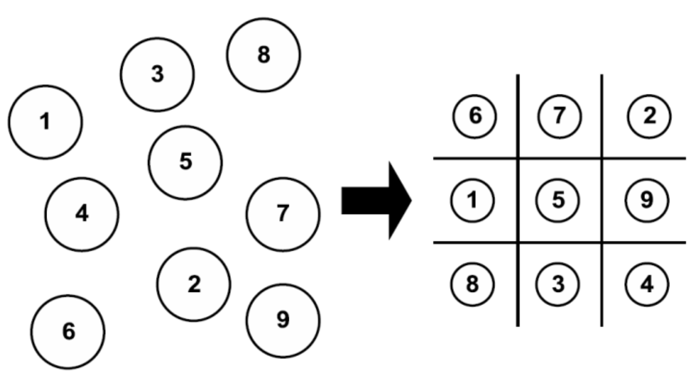

Figure 1. An isomorph of the game Tic-Tac-Toe

The challenge of designing an appropriate emergency exit plan, for example, could be isomorphed using the familiar Where's my Water game mechanic [60]. In this mechanic, a material must flow from one place to the other. The player is responsible for deciding which gates to open, close or construct. The problem can be further complicated by providing multiple sources of water, allowing players to construct flow directing items, etc. To isomorph the problem, developers could construct levels representative of the space for which they need to construct an exit plan. The game could employ basic models of crowd simulation behavior (slowing when dense, directing toward visible spaces, etc) to allow players to get as many people out of the building as quickly as possible.

Abstraction is essential to isomorphing. The primary benefits of proper abstraction are similar to abstraction in software design. When done correctly players know only what they need to know. Players should also be able to use as much extrinsic knowledge as possible, so that they are able to problem solve without the complications of understanding intrinsic, game level exceptions to the world they know.

The hypothetical benefits of abstracting an isomorph include:

- **Refinement through practice**: players are more likely to try to solve a game problem multiple times if they understand the problem as part of a game.
- **Fictionalization adds engagement**: as evidenced by a collection of game design studies [61] players' engagement is related to the constructed situation of a game. The fictions which perpetuate game tie into the human interest in story.
- **Experimentation in play:** As demonstrated in simulation games, players are afforded the opportunity to learn through experience. Psychologists understand play as essential to learning [2]. Essential to that learning experience is the understanding that it is okay to fail in a game. By

definition, a game is a safe place in which to experiment, as it is independent of the real world[2]. Isomorphs promote this understanding, by abstracting the problem.

4.Analysis

Analyzing Human Computation Games

In order to better understand the current state of practice in human computation games we conducted a content analysis of several human computation games. This first approach was to catalog 10 common human computation games. This analysis was informed by a larger study conducted by the authors on 200 persuasive play games[62]. Since the advent of human computation games is fairly recent it seemed premature to use the complete 55 element analysis. Instead we provide an analysis outline the 5 structural aforementioned elements of game mechanics. The resulting table is listed as table 2. This simple analysis was designed to capture the structural characteristics of these games. Such an analysis yields a basic topography of pattern in the designed experience and problem solving approach of human computation games.

Game	Competition	Implements	Territory	Inventory	Rules
Swarm-Miner	Route optimization, Most optimal path solutions	Pheromone doping, Path killing, path rerouting	Puzzle space; collections of ’cities’ and their distances	Best path length, number of ants participating	User may promote and demote path sections with pheromone, Users may reroute continuous sections
Foldit	Solve protein folding puzzles as close to a native protein form	Rubber Bands, Shake, Wiggle, Freeze	Game space is confined to protein components in a ’manipulating space. Many protein puzzles	Points based on speed of solution and how well-folded the solution is	Users may use a variety of tools to fold a protein to a specified degree
ESP Game	Guess the same words to describe images as your partner	Intuition, Entering guesses	Theoretical territory: Specified images on the Internet	Score (time to match), accumulate potential matches with each photo	Users type suggestions but Cannot communicate with one another, they must try to guess what their partner thinks of an image

TagATune	Determine whether or not you and your partner are hearing the same song	Describing Songs, Intuition, Partner Responses	Theoretical territory: specified songs	Score based on number of mutual agreements between partners	Users must declare whether they are listening to the same song as their partner based on description
Intentions	Determine whether or not you and your partner had the same intentions for a web search	Intuition on how to answer a question, Partner responses	Theoretical territory: Specified questions which can be answered by the Internet	Points awarded for mutual agreement on sameness of search intention	Users must enter a search query they believe to be relevant to a question or ”intention”; Partner's query is visible to user
Magic Bullet	Agree upon CAPTCHA character with partner before other team agrees	Intuition of CAPTCHA characters	Theoretical Territory: specified possible CAPTCHA characters	Targets are hit, corresponding to points, for fastest user-partner agreement	4 players split evenly into two teams. Each team attempts to agree upon their CAPTCHA character

Verbosity	Guess the word that your partner is describing and describe for partner	Common sense descriptions	Theoretical territory: specified words that can described	Points based on number of correctly guessed answers	Users guess words that their partner is describing with common sense facts about the word
Geocaching	Exploration and Discovery	Geocache Map, GPS	Territory: Earth	'Rank' determined by items 'found' through exploration	Individuals can find and hide Geocaches around the globe and locations are put in the Geocache map for other users to discover
Phrase Detectives	Analyze the most documents for relationships between words and phrases	Grammatical and semantic knowledge, four decisions for phrases	Theoretical Territory: specified written works	Rank determined by the number of documents completed	- Users give insight on phrases in documents to 'complete' documents and score points
Little Search Game	Refining searches to yield the smallest number of results for specific words	Intuition	Theoretical Territory: Words specified by the game interface	Ranked based on how few search results can come from a query related to a specific word	Users attempts to refine a search through negative keywords as best they can using only 6 'negatives'

This analysis demonstrates that several games rely on very conventional inventory as player progress. Scores or points are integral elements of the designs in FoldIt, ESP Game, TagATune, Intentions, and Verbosity. Similarly Geocaching, Phrase Detectives, and Little Search Game all use ranks which are essentially relative scores.

Competition within the games is fairly diverse. The most common approach is to pit one player against the other in solving a common problem. This approach is particularly apt for situations in which the correct answer is one of social contract or agreement, not natural science. TagATune, Intentions, and Verbosity aim to solve a problem for which agreement are the problem being solved. Geocaching, however, is much less explicit in its structure for competition. The competition is shared with all explorers, the challenges of merely moving through time and space. This model is unique and important as competition is innately supportive of experimentation. Players of such games are simply given a goal. The means to achieving the goal, or the implements are not limited. Such play afford for a wide set of players, skill sets and play types (e.g. in a car, on a bike, as a group, or alone). Yet, we understand the biggest benefit to such play within HCG is not in understanding that the goal can be achieved, but in understanding how the goal was achieved. Much like FoldIt's archive of player solutions, exploration and discovery as competition provides an impressive potential for offering unthought-of of solutions. In analogy to history, explorers have demonstrated to society that a place can be reached, but it is an understanding of how they reached it that the greatest social good was achieved.

This is an important distinction in competition models. Social contract games as mentioned are centered on consensus. The games work like polling systems. Players provide answers and success is most often associated with the player's ability to match the findings of others. Oddly, this is the antithesis of the scientific method. In theory, these social contract games seeking to affirm not disprove. That is not to say that what these games do is bad. Their efforts are appropriately matched to their efforts, as we do not define many words by what they are not and we do not understand music by what it fails to sound like. However, it offers an important footnote. The bulk of HCG solutions employing social contract models seem well poised to prove, not disprove.

Without much of a stretch, it is easy to imagine a game in which players are rewarded for finding the least common solution. This is focus of creative thought. Instead of affirming standards, it can afford the requisition of new solutions. In practice, the Persuasive Play Lab at Miami University is developing a game that employs Alternate Reality Gaming to allow players to vote on works of art. The players, as part of an installation at the Columbus Museum of Art [63] must collect geometric shapes and combine them to unlock game sections. From testing, the first players will combine pieces in very traditional ways (e.g. two equilateral triangles to create a square). However, because the game system only allows a single permutation of a geometric combination, subsequent players are taxed with diving new combinations. As the game progresses, determining useable configurations becomes a more and more challenging creative skill. A game system using this type of competition could be employed to solve practical problems like pattern recognition for IQ test or military and social situations that extend beyond traditional game theory.

This analysis also demonstrates that many games in HCGs do not offer clear territory. In particular, systems such as the ESP Game, have at best a territory defined by the conceptual agreement of two players to compete. Structurally, the design of the ESP Game is as much a test or poll as it is a game. The key elements of the structured system include clear competition and a scoring system. This is perhaps a result of the nature of the HCG domain. Much like serious games, there are many systems which are playful but not clearly games. In the early days of serious games, many simulations were labeled games. In that practices evolution, the distinction has become clearer. It is generally agreed that simulations are generally prescriptive, basing their experience on the realities of their subject. Games are abstractions that afford experimentation, consequently departing from prescriptive experience and behavior to a subscriptive model. In our experience, games are designed for play, while simulations are designed for analogy. Under such a model, the ESP Game may not be a game because it offers only marginal support for play. Further discussion of the theory of play, simulation and test systems is beyond the scope of this chapter.

5. Models for Ubiquitous and Persuasive Play

Ubiquitous Play and Alternate Realities

If ubiqitous computing is the near future, its compliment is ubiquitous play. Ubiquitous play is most commonly occurring through location based play and alternate reality games. Location based play employs location aware systems like GPS in the service of exploration and treasure hunting. These play activities include geocaching, the use of social networks like Four Square and less technically via street games [64]. Players participate by physically moving through spaces and allowing their locations to be tracked.

Such games are typically either active play or passive play. Active play includes activities like geocaching where play follows the conventional definition of a game, offering a clear beginning and an end. Players must accept an active role in perpetuating the gameplay experience. They must engage with play through active use of a device or self-initiated interaction other players. Passive play is the model of social networking sites that automatically log player locations via smartphones and provide achievements, badges, etc for visits. Passive play games require no self-initiated interaction with players or technical game elements. Passive players do not need to check their smartphones to perpetuate play. The game happens to them, it does need to be operated by them.

Passive play is a particularly notable, because play really happens at two levels achieving a very clear ubiquity. Players join the play space by agreeing to participate. The play requires little from them from then on. Instead players can choose to check in with their play at any time in any place. In some ways they are always available to play, a kind of ubiquity in itself.

Alternate reality games converge with ubiquitous computing in their conceptual approach. Alternate reality games are subscriber fictions. Players are provided an inciting event called the rabbit hole. This might be a problem that requires mass participation (e.g. find the missing item) or a complicated puzzle (e.g. what does a set of letters mean). The first alternate reality game of international fame was The Beast, to promote the movie AI [65]. The most notable was I Love Bees game to promote the release o f Halo 2 [65]. Alternate reality games have been theorized as presenting both active and passive play, as some have claimed that the activity of spectator play in alternate reality games is a kind of passive play. The logic proceeds that unlike a spectator sport, in which one watches but does not play, the act of subscribing to the fiction of an ARG is a type of play.

The design and execution of alternate reality games is unique. The games are not designed like software projects, where much of the experience is known before release. Instead they are design and executed in real time. Designers of these games change the game as it is being played, adapting to the needs of the playing audience. The most analogous design model is the massively multiplayer online role playing game, or MMORPG, [65], which relies heavily on subscribed players.

Jan McGonagall has used ARG's to propose solutions to complex problems. A world without oil, for example, requires players to live their lives without the prevalent oil resources, Players subscribe to the fiction that all of the oil in the world has been depleted. They must then find a way to live their daily lives without oil, designing new ways to work and enjoy life. Players deposit their experiences and solutions in web spaces (e.g. forums, emails, etc) which afford qualitative research.

The theoretical benefit of combining ubiquitous computing with alternate reality games is quite clear. Players can participate in ubiquitous game playing while providing computationally useful information. A passive ubiquitous game might include solving the problem of planning construction in an urban environment. Players might be asked to subscribe to the fiction that a set of streets have been blocked. Players then choose appropriate paths to avoid the streets. Where computing resources might project a path based on encoded behavior, a set of players may reveal new patterns. Players might, through play, expose an alley convenient for pedestrian traffic not revealed on maps. They might also demonstrate behavioral changes, such as increasing the number of purchases at a specific coffee shop or slowing vehicle traffic because of increased pedestrian populations and j-walking.

Ubiquitous Personalized Play and Field Research

Personalization of game experience evolved from a need to both widen game audiences [66] and increase the depth of experience. The most basic games employ simple tactics like avatar customization to allow players to experience a light degree of personalization. More advanced games personalize the experience based on the needs and interests of the players. This is particularly common in MMORPG. In MMORPG games designers review and respond to player metrics including play session length and player uptake. Future scenarios are scripted to respond to player demand. Alternate reality games follow a similar model. An ARG is rarely written from start to finish, instead the rabbit hole is setup and the game designer reviews player data to determine the next appropriate events to propel play. Unlike traditional designs which require a solid blue print before the game is implemented, these games require design on the fly.

The reason both MMORPG and ARG's design on the fly is that the game depends strongly on sustained subscription. Players' interest must be maintained over weeks, months or even years. As the number of players decreases, the experience for all players declines. Players on the other hand commit long periods of time to the game worlds because the world changes with the needs of the game playing populace. Players of MMORPG in particular spend time building player characters that are the fundamental unit of operation within the game. The result is an experiential personalization. Players experience the world, their character earns experience points for the things they do in games (e.g. raids, missions, etc). The more the player participates the more efficacies they earn. The efficacy is earned by developing a character through experience.

Some types of games well suited for human computation games will need a set of specialist problems solvers. As the complexity of problems solved through HCG increases, designers will find need for players who understand more complex relationships. Even through well conceived isomorphs, the quality of solutions will depend on careful execution of multi-factor problems. This is where personalization becomes exceptionally handy in keeping players. As evidenced by MMORPGs and ARG, players can remain engaged in a game for a long period of time. That prolonged problem solving can support an HCG that is less about small problems processed in parts and more about large problems that need to factor large scale issues.

In particular, a designer could reasonably conceive of a set of ubiquitous games that requires players to check into specific locations over a long term. The player creates an alternate self in the fiction of the game world and proceeds to take assignments provided. Perhaps the game is isomorphed and wrapped in the fiction of a spy novel. Players earn points for their normal travel and receive puzzles and missions relative to their normal travel behaviors. The player may be asked to find another way through a traffic jam, take a smart phone picture of a specific location at a specific time, or count the number of people at a particular park at a specific time. These missions might feed a traffic calculator, a visualization tool, or a city planning census.

Players may choose to attempt alliances with other players and drive the game's plot. Players might get distracted on their path to a mission. The game could suggest new missions as changes arise, requiring players to collect new data. The game could request players reevaluate other player missions, assessing data integrity for data they deem unreliable. In short they may personalize their game experiences.

The more missions the player completes, the higher their spy rank climbs. Spies with higher rank earn abilities not available to less experienced spies. Perhaps the players earn the ability to see the activities of other players or the ability to choose the missions they complete. As they build their character in the fictive world, they increase their efficacy in the game world. Players may become spy specialists in their hometown or a favorite vacation spot.

In this scenario, the player is not terribly interested in the fact that they may be collecting scientific data about the places they travel or delivering consumer habits data to the varied travel bureaus of the areas they visit. They do not need to know that they are acting as field researchers collecting and depositing useful observational data. It does not matter that such a game interested pervasive games, location-based games and alternate reality games and MMORPG. Instead, their intent is to improve their character. A character which may be interchanged with other games or may even provide non-game benefit through spy rank-specific social gatherings.

Such a game is only a step beyond the existing standards of earning badges and becoming mayor of specific locations because the aforementioned scenario is more than a basic matriculation schedule. Players are building an identity and personalizing their experience, not just a profile. Players are also creating an alternate identity that can be transferred between multiple games. They are also being asked to complete tasks which are easily recorded via ubiquitous computing.

Ubiquitous personalized play supports a few of the common challenges of successful HCG. Ubiquity simplifies the play experience, mitigating the need for players to understand complicated user interfaces.

It also reduces the need for players to withdraw from other experiences in order to play. Players continue to earn the benefits of play, but instead of telling a spouse or child that they must sequester themselves to a desktop or console to play, they can instead allow the Internet of things to support their play.

Yet the critical component is the sense of personalization. Players are building something which is unique to their experience and potential portable. If they choose to embark on a new game, they are not starting fresh. Instead they are building, and thus personalizing, what they have already started.

Complications in the Use of Ubiquity in Human Computation Games

The benefits of these approaches do come at a potential cost. The complication to the evolution of ubiquity and productive play in HCG is the existence of persuasive play. Bogost [67] and others have demonstrated that play can be persuasive. Play experiences can drive understanding of concepts. It can also change the way players perceive and solve a problem.

Considering games as media, it is clear that games also offer the potential to provide a kind of media rhetoric. If games support solution finding, they may also drive those solutions in specific directions. It is not unreasonable to think that a game may use the power of thousands of players to prove incorrect theorems. The fundamental dilemma is that game systems are constructed fictions. As fictions they are under far less scrutiny than analogous simulation systems. Issues of morality and mutual benefit may succumb to the desire to win. In player terms, a system could be inadvertently or purposefully gamed. Through this lens, games that employ human computation seem to have the potential to evolve toward decision support systems. Yet, when combined with the complications of captology [68], there is a dilemma. How does one define the objective resolution when the system is designed to solve such problems? If the software systems within games are subject to the same potential biases proposed by captology, there are a host of design and software ethics questions that need to be asked. The answer to these questions are beyond the scope of this chapter. It is however worth reminding potential HCG developers that with the great potential power of HCG and ubiquitous gaming, comes great responsibility. In particular designers of HCG should be cautious to avoid creating experiences which inadvertently employ procedural rhetoric in the pursuit of satisfying game experiences.

Conclusion

The authors have attempted to provide a set of design and development considerations for human computations games and their potential within the ubiquitous game domain. This is a fledgling enterprise in which many heuristics are acquired through the careful analysis of success and failure in allied practices. Alternate reality games, ubiquitous computing, and crowdsourcing offer clear connections to the task of design and implementing ubiquitous human computation games. To some extent such games require the fundamentals of game design coupled with proper experiment design. The benefits of such techniques are also quite clear. By coupling appropriate isomorphs and applying iterative observational resourcing, research can be more easily conducted across cultures. To some extent, games can afford disenfranchised populations the ability to participate in the resolution of wide problems. Likewise, many such games can employ existing infrastructure, reducing the need for travel by field researchers by converting game players to observational data collectors. It is also clear that iterative observational resourcing expands opportunities of metadata enterprises.

On the other side of the equation, iterative computational resourcing provides exceptional opportunities to change the types of problems solved through computing paradigms. In particular, the combination of ubiqitous computing with computational play bridges the poorly explored gap between audience and developer. The novelty of such play may initially solicit the type of attention HCG developers seek to increase player subscriptions. Long term, other strategies will need to be investigated to excite players toward such play.

The beauty of the opportunity in ubiquitous human computation play is that employing the human cloud can happen by extending existing networks with play. It is a reasonable evolution to address the many challenges with computation play while nursing the computational benefits of that same approach.

It is clear that success relies on employing the fundamentals of games design, while offering few barriers to new player entry and engagement. In short, HCG games must be at least as attractive as other game experiences, or they will fail to attract people away from traditional play. Much like other competitive marketplaces, once the novelty of playing an HCG wears off, the environment for promoting and HCG will become more competitive. Ubiquity eases player participation, while personalization retains them as players.

This is marked difference to the current direction of HCG games which rely heavily on the casual gameplay model of short, puzzle-like simple play. It is not that such play experiences are not appealing, but more that HCG should be taking advantage of the full potential of its audience and medium. Longer term play provide for prolonged commitment by players will effect the types of problems addressed. Just as researchers get better as they practice researchers, players may get better as the play more HCG games.

Lastly, it is important to understand that human computation games can extend across a wide set of domains. It is just as feasible to imagine an HCG game that helps determine the most appropriate language in a specific context, as it is to imagine scientific problem solving. Such a dialogue game could help refine automated computer systems, but to do so, the HCG may need to employ non-casual story-based play. The fundamental concept is a reversal of the relationship between computer and human. It is a somewhat symbiotic one, where the player is training the computer.

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