Balancing Multiplayer First-Person Shooter Games using Aiming Assistance

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***Abstract* — When player skill levels are different in competitive First Person Shooter (FPS) games, the weaker player can end up feeling discouraged and the stronger player may get bored with the lack of challenge – ultimately yielding a non-optimal play experience for both players. Previous work has investigated how aiming assistance can be applied in a 3D environment to assist weaker players; however, there is little information on whether aiming assistance balances gameplay in a multiplayer environment or on how aim assistance affects player experience. We carried out a study to test the effectiveness of two aim assistance techniques (Bullet Magnetism and Area Cursor) that have been shown to help aiming in a 3D FPS. Our study had novice-expert pairs play deathmatch games in a multiplayer 3D FPS with and without the assistance techniques. The study showed that although Area Cursor and Bullet Magnetism resulted in better performance of the weaker player, it did not result in closer scores, and had no effect on the players' enjoyment of the game. Our results indicate that balancing performance in 3D FPS games is more complex than simply helping weaker players' aim, and we suggest possible reasons that warrant further investigation. This study is the first realistic evaluation of balancing techniques for 3D First Person Shooters, providing empirical evidence of the difficulty of using aim assistance techniques for balancing competitive gameplay.**

Keywords — Aim assistance; FPS games; game balancing

I. INTRODUCTION

Video games are currently one of the most popular types of media, with almost $20 billion spent on video gaming in 2012 [7]. First Person Shooter (FPS) video games are one of the biggest and most popular genres of video games, making up 21% of games sold in 2012 [7]. FPS games require skill and quick thinking to navigate through complex 3D environments while dodging enemy fire and firing back. The emphasis on skill may explain why a major source of motivation to play FPS games is the competition [26].

While competition is a big part of the draw of FPS games, it brings in complications in achieving game balance when players do not have as much experience or skill as their opponent. When games are unbalanced, players do not have as much fun [22][26]; when players do not have fun, they will not want to keep playing the game, which might negatively affect sales. In addition, providing a way to balance play could attract a larger and more diverse audience to FPS games, which could positively affect sales.

Because aiming is a major factor in FPS performance that differentiates expert players from novices, one solution for balancing gameplay is to use *aiming assistance* to help weaker players. Aiming assistance improves the accuracy and speed of target acquisition by modifying factors like the size of the target or assisting the user's aiming trajectory. Aiming assistance has proven successful at improving performance for novices, and at balancing gameplay in multiplayer 2D shooters [4]. In 3D FPS games, aiming assistance has been shown to improve performance for single players in simple scenarios; however, the addition of realistic game elements such as distractor targets, enemies that move and shoot back, and advanced weapons reduces the efficacy of the techniques [25]. Because multiplayer scenarios further increase the complexity of the environment, it is unclear whether aiming assistance can be used in competitive FPS games to balance play.

In this paper, we investigate the efficacy of aiming assistance for balancing gameplay in multiplayer FPS games. We implemented a custom game using the Unreal Development Kit, and then used this game to conduct a study involving pairs of players competing in a deathmatch game. The game dynamically applied two aim assistance techniques (Area Cursor and Bullet Magnetism) that have been shown to be effective in FPS scenarios [25], and a control condition with no assistance. Aiming assistance was given to the weaker player dynamically according to their performance (as defined by the relative number of kills). Our findings indicate that while the performance of novices was increased when they used aiming assistance, the actual game score was not affected by the inclusion of aiming assistance. Therefore, our results suggest that targeting assistance techniques alone are not effective in a First Person Shooter game to balance gameplay or increase game enjoyment (at least between pairs of novices and experts). We suggest additional methods that can be used in combination with aiming assistance to balance play.

II. BACKGROUND

A. *Game Balancing and Player Balancing*

A game is considered balanced when the challenge of the game matches the skill of the player [8]. This is considered the optimal challenge level – otherwise the game is too easy or too hard. At this optimal balance level, the player's anxiety and boredom levels are also balanced, meaning the player is not frustrated or disengaged [24].

Competition has been shown to be key for the enjoyment of video games [26], but in competitive scenarios with other human players it is difficult to keep the game balanced if the players do not have equal skill [2]. Keeping the definition of balance in mind, in order for a multiplayer game to be balanced, all players should have an equal opportunity to win [1]. This type of balancing (balancing amongst multiple players of variable skill or ability) is *player balancing*. Player balancing is important because when the players are evenly matched, enjoyment is increased for both parties [4].

This behavior was demonstrated in a study of competition between siblings during gameplay, in which the younger child became upset or lost motivation to continue playing if they were never able to perform as well as the older sibling [12]. While this study was aimed at investigating the multiplayer habits of young children, the findings likely extend to interactions in other multiplayer situations.

The issues of balancing competitive multiplayer games have led to research into ways of achieving this balance. The general approaches game developers and researchers have developed to solve the gameplay balance problem can be categorized into four general categories [4]:

1. Difficulty Adjustment: One of the most common ways of balancing is to adjust the level of challenge in the game. This type of balancing can be either static or dynamic.

The static approach allows the player to explicitly select a difficulty setting (like "easy", "intermediate", or "hard"). This is an approach that is mostly used in single player games. The problem with static difficulty settings is that once a player chooses a difficulty, they are generally locked to this level for the entire game, or the player may miss out on special rewards or unlockables if they change it mid-game. Additionally, players are expected to choose before they know how hard the levels are. For example, players do not know how hard "hard" is until they've played the game.

Dynamic difficulty adjustment is used in games such as *Mario Kart* (where players that are farther behind are given better powerups) or *Left 4 Dead* (AI Director). These systems adapt and respond to the abilities of a player during a game session [15]. Artificially balancing games can lead to higher player enjoyment, as long as the participants are not aware they are being helped [4][11][12]. It had been shown that players who are not assisted can feel cheated of a victory that should have been theirs [22]. Additionally, it has been shown that the assisted player may feel like their performance was entirely due to the system helping them, and feel discouraged or feel that their achievements are meaningless [11][12]. This will also mean that the assisted player will miss out on the enjoyment that comes from finally beating something difficult. Therefore the system must be unobtrusive and not noticeable in order to be effective [16]. An example of an obvious balancing mechanism is the "rubber band" adjustment such as that used in *Mario Kart*, which gives trailing players better items. These "rubber band" techniques are highly noticeable, and can make other players feel cheated [11][15].

A major benefit to dynamic systems is that they reduce the need for iterative refinement based on play testing, because the system regulates the difficulty itself [16].

2. Matchmaking: Matchmaking systems are popular in online games. For example, *Dota 2*, *StarCraft 2*, and *Halo* [14] try to match players who have the same level of experience or ranking to ensure the level of competition is balanced [22]. *StarCraft 2* matches players into different tiers (Bronze, Silver, Diamond, Master, etc.) based on performance [18]. The problem with matchmaking is that the system may not always be able to match up players of equal skill, and must compromise based on the available players. In addition, matchmaking does not help when two individuals know that they want to play together, but are unevenly matched.

3. Asymmetric Roles: Some games allow for several different roles for people who have different skills. For example, *Team Fortress 2* allows players who are skilled shooters to choose a class such as the sniper; otherwise the player can choose a class such as the medic, whose task is not focused on shooting, but rather on healing and supporting other players. These games are carefully designed to ensure that every class contributes to the team and no one class is considered unnecessary. The drawback is that some players may not like feeling forced into a certain role and that playing these specific roles may not help players improve their skills.

4. Aim Assistance: Using aiming assistance to balance gameplay has only recently been investigated as a way of solving the balance problem in games that use targeting as the primary game mechanic. Target assistance has been shown to be effective at improving competition in 2D games where players have uneven skill, using techniques developed from traditional 2D targeting assistance work [4]. The assistance was not noticeable and participants noted they had increased enjoyment in games where assistance was present.

B. Aim Assistance and Virtual Pointing

The foundation of virtual pointing is in Fitts's Law [10], which predicts the amount of time (MT) it takes to point to a target of a particular index of difficulty (ID). In (1), a and b are empirically determined constants, W is the smallest of the width or height of the target, and D is the distance from the current location of the cursor to the target. This equation states that the smaller and farther away an object is, the longer it will take to acquire. While Fitts's Law was originally meant to model physical pointing, it has been shown that it also models virtual pointing and forms the basis of all pointing work done in HCI.

$$MT = a + b\,(ID) \qquad ID = \log_2((D/W) + 1) \qquad (1)$$

In physical pointing, there is a one-to-one mapping between the visual space and the motor space. Virtual pointing has three spaces: the motor space (physical movements of the mouse), the visual/display space (the space on the monitor), and the control to display space that links both (the intermediary device that converts how much physical movement moves the object in visual space such as a mouse and driver) [3]. The control to display (CD) ratio is a number that describes this third space and represents how much physical movement corresponds with how far the cursor moves on screen. This additional third space means that pointing in virtual spaces is not limited by the same things that limit physical pointing, because it is possible to manipulate the control to display space to allow systems to make pointing easier [5].

The underlying movements in virtual pointing can be described with the "optimized initial impulse model". This model says that pointing consists of two parts, a ballistic phase and a corrective phase [3][9]. In the ballistic phase, coarse initial movement is made towards the target. If the pointer manages to land on the target, then no more work is needed because the pointing task is done. If it ends up outside the target, a secondary phase of fine movement is needed to correct and reach the right location on the target.

With these ideas in mind, three basic approaches have been developed to facilitate pointing:

1. Reduce D: These solutions try to reduce the amount of distance between the cursor and the target. This reduces the Index of Difficulty, which reduces the total movement time in the Fitts's Law equation. These solutions modify the first, ballistic phase in the optimized initial impulse model. An example of this would be to change the linear list that appears when a user right clicks to a pie menu where each item is the same distance away from the cursor.

2. Increase W: These solutions try to increase the target size in either visual or motor space. These solutions target the second, corrective phase of targeting in the optimized initial impulse model. An example is the fisheye method, implemented in systems such as Apple's dock, which involves dynamically expanding targets as the cursor nears a target. Visual only expansions only increase the size of the object on the display. Motor expansions, however, increase the size of the object in motor space, meaning it takes more physical movement to cross the target. Research has shown that visual only expansions result in poor performance, and can even hinder the acquisition of targets because they lead to overshooting and confusion [3].

3. Reduce D and Increase W: This category combines the first two approaches by reducing the distance to the target and increasing the size of the target. An example is the Angle Mouse technique [27]. This system changes the control to display ratio depending on the current phase of pointing to simulate the effect of reducing D and increasing W. It lowers the control to display ratio when it detects that the user is in the ballistic phase (assumed to be when straight linear movement occurs), reducing the distance because it takes less physical movement to move the cursor to the target. When small quick movement is detected, the system assumes the second corrective phase is active, so the control to display ratio is increased, making the object bigger because it takes more physical movement to move the cursor.

Most of the previous work in using these approaches for targeting assistance has been focused on helping people who are older or have a motor disability use a computer to select items (like buttons, other targets) in 2D interfaces. Bateman et al. conducted some of the only research into using targeting assistance in a game environment [4]. Recent work has also been done by Looser et al. to show that the Fitts's Law equation holds in 3D virtual spaces as well [19]. This suggests that the targeting assistance techniques that have been developed can also be applied to 3D games with good performance. However this assumption was tested and found to not be quite true [25] in a series of studies in a single-player 3D FPS game environment. The only traditional technique that was found to improve performance was the Area Cursor technique (covered in section 3.1). The general results from this series of studies stated that techniques that do not interfere with targeting and that activate once the shot has been fired resulted in the best performance improvements. These techniques give players a feeling of autonomy and competence, which as noted by Ryan et al., results in increased satisfaction [23].

C. Aim Assistance in Commercial Games

The use of targeting assistance techniques in commercially available video games are confined to console games that use gamepads as input; computer (PC) games do not generally employ targeting assistance because mice are more precise than gamepads [21]. The four common approaches for aiming assistance in console games are Bullet Magnetism, Target Lock, Sticky Targets, and Target Gravity. Bullet Magnetism will be described in more detail below. Target Lock involves pressing a button and having the crosshairs move to the closest opponent, used in *Red Dead Redemption* [25]. This method is based on the "object pointing" interaction technique, which tries to reduce empty space between targets by moving between selectable targets [13]. Sticky Targets gives opponents a sticky effect when the cursor is on them, increasing the size of the object in motor space and is used in *Call of Duty* [3]. Target Gravity is like a passive version of target lock, which nudges the crosshair towards opponents based on their positions and is also used in *Call of Duty* [4]. Despite the fact that targeting assistance is used in some games, no commercial game has tried to use these aiming assistance techniques as a player balancing mechanic.

III. EXPERIMENT

A. Techniques Chose for Comparative Study

Bullet Magnetism and Area Cursor were chosen as aiming assistance techniques for player balancing. These were chosen based on previous work into the effectiveness of different techniques in 3D FPS environments [25], which showed that Bullet Magnetism and Area Cursor tended to perform the best and had minimal noticeability. These techniques were implemented in a game developed using the Unreal Development Kit (UDK). It is important to note that the previous study measured aiming assistance performance in a single-player system. This study applies aiming assistance amongst multiple players for player balancing.

Our study uses dynamic difficulty adjustment to decide how much assistance to provide. The dynamic difficulty system works by giving the weaker player (defined as the player with fewer kills) a certain level of aiming assistance. The system has 10 levels, where 1 is the lowest and 10 is the highest amount of assistance possible. The level of assistance is calculated by subtracting the number of kills of the weaker player from the number kills of the player in the lead. For example, if the current leader has 5 kills and the other player has 1 kill, the level of assistance for the player with 1 kill will be 4. The player with 5 kills has the level of 0, or no assistance. The amount of effect of each level of aim assistance was determined by pilot studies and previous studies [25] and is described below.

1) Bullet Magnetism

The Bullet Magnetism technique basically "bends" the bullet towards the closest target if a target is within the activation range. The end effect can be seen in Fig. 1. Bullets in the UDK game that was used are instant shots and are therefore described by a vector. The vector is adjusted towards the first enemy that is within range (160 UDK units * Level, where $1 \leq \text{Level} \leq 10$) of this vector when the player fires and before the bullet collision logic. Bullet Magnetism is applied towards the body of the enemy if the crosshair is off the target and to the head of the enemy if the crosshair is already over a target. The higher the level of assistance is, the farther away the effect begins and the more the vector is corrected. Additionally, the closer the player is to a target when shooting, the more the bullet is attracted to the target.

This end effect is similar to the Area Cursor method (described next) because it allows players to hit targets without perfect aiming, essentially increasing the target's width. However the visual feedback is different (fired shots bend instead of showing a bigger cursor). The useful thing about this method is that it does not move the crosshair or change the CD ratio so it is less intrusive than other methods [25]. However, Bullet Magnetism may have issues if distractor targets are present as it may be attracted to the wrong opponent [25].

Bullet Magnetism is not based on any targeting assistance or Fitts's Law research. It is a technique that can be used in first person shooters because of the presence of bullets, which regular interface selection does not have. This technique is present in games such as *Halo* and *Gears of War 3*.

2) Area Cursor

The Area Cursor technique follows the original 2D implementation [17] with modifications to work in a 3D environment. Normally when a shot is made in the implemented game, a zero-extent trace is used to determine if a target has been hit by the bullet. The Area Cursor assistance technique uses a rectangle/non-zero-extent trace to test intersection. This can be thought of as a larger bullet being fired. Intuitively it seems obvious that a bigger bullet will make it easier to hit a target, and is confirmed if this technique is thought of in terms of Fitts's Law. It has been shown that increasing the size of the activation area is the same as increasing the width of the target [17] meaning bigger cursors lower the index of difficulty and movement time.

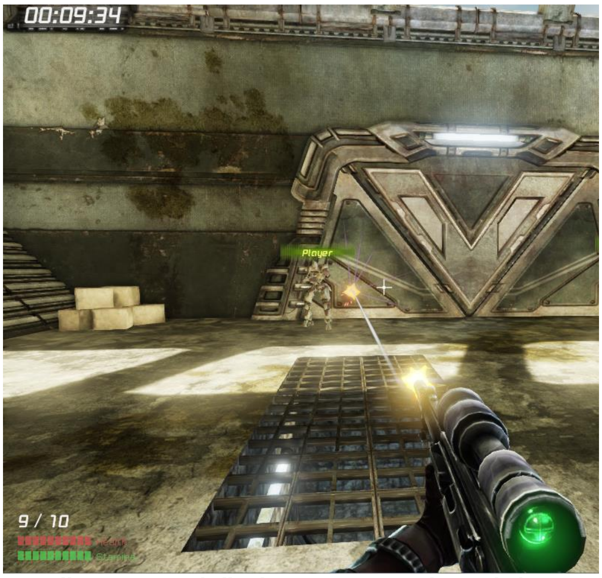

Fig. 1. Bullet Magnetism: bullet direction is corrected towards the target.

In the game implementation, the size of the crosshair changes as the activation area changes. Normally the regular crosshair radius is 10px on the screen. When Area Cursor is used, the size of the crosshair radius is 10px + (5px * Level) where $1 \leq \text{Level} \leq 10$. This reflects the size of the activation area/rectangle used for intersection. This means that less precision is needed as the assistance level is increased. In pilot studies, the growth of the cursor was subtle enough that users did not notice it growing.

This technique was chosen because of its performance in 3D environments [25] and because of the successful results at balancing in 2D environments [4]. Area Cursor has also been shown to improve targeting performance for older adults [28] and users with motor impairments [9]. The technique's performance does not degrade in situations with moving targets like other assistance techniques. However, "sloppy targeting" behavior may appear if players become accustomed to the extra activation area [6]. Distractor targets can also become a problem if the cursor is too large [17]. Our implementation handles this multiple targets issue by choosing the target closest to the center of the crosshairs. This method also does not directly help players get headshots, unlike Bullet Magnetism. The player will still need to center their crosshair over a target's head.

IV. Study Description

This study extends previous work in aiming assistance in FPS games, which established that aiming assistance techniques can work in a single-player 3D FPS scenario [25]. In our study, participants were matched with a single opponent in an FPS game, played with a keyboard and mouse on a computer. The goal of the experiment was to evaluate the efficacy of the Area Cursor and Bullet Magnetism targeting assistance techniques for player balancing. Participants played one round with each technique with an additional round as the control (no assistance). Participants were given an extra round with no assistance for training before these three rounds.

A. Participants and Apparatus

Ten pairs of participants were recruited from a local university and given course credit for their participation. Participants ranged in age from 18-29 (mean 21.5). Prior to the study, participants were asked to fill out a questionnaire about their gaming habits and FPS experience to sort them into either a "novice" or "expert" category.

The game was developed using the Unreal Development Kit (UDK) to test the balancing capabilities of aiming assistance. The UDK game was developed in the UnrealScript language, using Visual Studio 2010 and the Nfringe add-on as the IDE. All sessions were played on Windows 7 machines with Intel Core i7-2600 processors, standard optical mice, and 22-inch LCD monitors with 60 Hertz refresh rates and HD resolution. Each participant was allowed to set custom mouse sensitivity. Logging was done to a Microsoft SQL Server 2008 R2 database.

B. Task

Novice participants were matched with an expert. At each session, the participant pair was told that they would be testing different game balancing techniques and that some of the rounds they played may have game balancing enabled. Then, the two players were instructed to join the server and play 4 rounds of a 1-on-1 deathmatch game. The map was a customized small version of the default UDK "deck" map.

The participants started the game with an assault rifle gun and a pistol. There were two points on the level that spawned sniper rifles the players could pick up. The assault rifle has a higher rate of fire than the sniper rifle but does less damage with each hit. Assault rifles need 10 body hits or 5 head hits to kill a target and the sniper rifle needs one head hit or two body hits. The pistol is slower and more powerful than the assault rifle, and not as powerful but faster than the sniper rifle.

The study consisted of one training round with no assistance followed by rounds of Bullet Magnetism, Area Cursor, and no assistance. The ordering was balanced across participant pairs using a Latin Square, and each round lasted 5 minutes. At the end of each round, subjective questions were presented to the participants on how fair they felt the game was, if they noticed assistance, as well as how they thought they performed and how they thought their opponent performed. Each session lasted around 30 minutes when accounting for survey completion time.

The player could control their view with the mouse, and opponents were shot by moving the center of the crosshairs onto the target and left clicking the mouse. Player movement was controlled with a standard WASD control scheme. During the training round, a full explanation of the controls was given to both participants.

C. Dependent Measures

To see if the performance of the novices became better with aiming assistance, we looked at four types of measures for both the novices and experts.

- **Score:** *Score Difference* is the average score difference between the two players.
- **Accuracy:** *Hit Ratio* is the number of shots that hit a target out of the total number of shots that a player took, and represents targeting efficiency. *Headshots* are the number of headshots a player made, representing targeting quality.
- **Performance:** *Kills* is the number of times the player killed the other player in the deathmatch.
- **Subjective Measures:** The *Fairness* of a match was recorded as a simple yes/no answer on a questionnaire. Participants were also asked who the *Stronger Player* of the match was. *Competence*, *Autonomy*, and *Relatedness* subscales from the PENS scale of player experience [23] and *Interest-Enjoyment* from the IMI scale of player motivation [20] were also used to gauge user experience.

D. Data Analysis

We conducted a RM-ANOVA with Assist Technique (Control, Bullet Magnetism, Area Cursor) as a within-subjects factor and Expertise (Novice, Expert) as a between-subjects factor on the dependent measures of kills, deaths, hit ratio, headshot ratio, and the experience measures of competence, autonomy, relatedness, and interest. An RM-ANOVA was also conducted on the score difference with Assist Technique as a within-subjects factor.

Type 1 error was prevented by using the Bonferroni adjustment on all pairwise comparisons; α was set at 0.05.

V. Results

Means and Standard Errors for all measures are shown in Fig. 2; our analysis of each dependent variable is given below.

Score Difference: There was no effect of assist technique on score difference ($F_{2,36}$=.105, p=.901, η^2=.008).

Accuracy: There was a significant effect of assist technique on Hit Ratio ($F_{2,36}$=4.2, p=.024, η^2=.19); pairwise comparisons showed that Area Cursor yielded a better hit ratio than control (p=.018). Although Bullet Magnetism yielded a better hit ratio than control, this failed to reach significance (p=.115); there was no difference between Area Cursor and Bullet Magnetism (p=.170). There was no effect of expertise

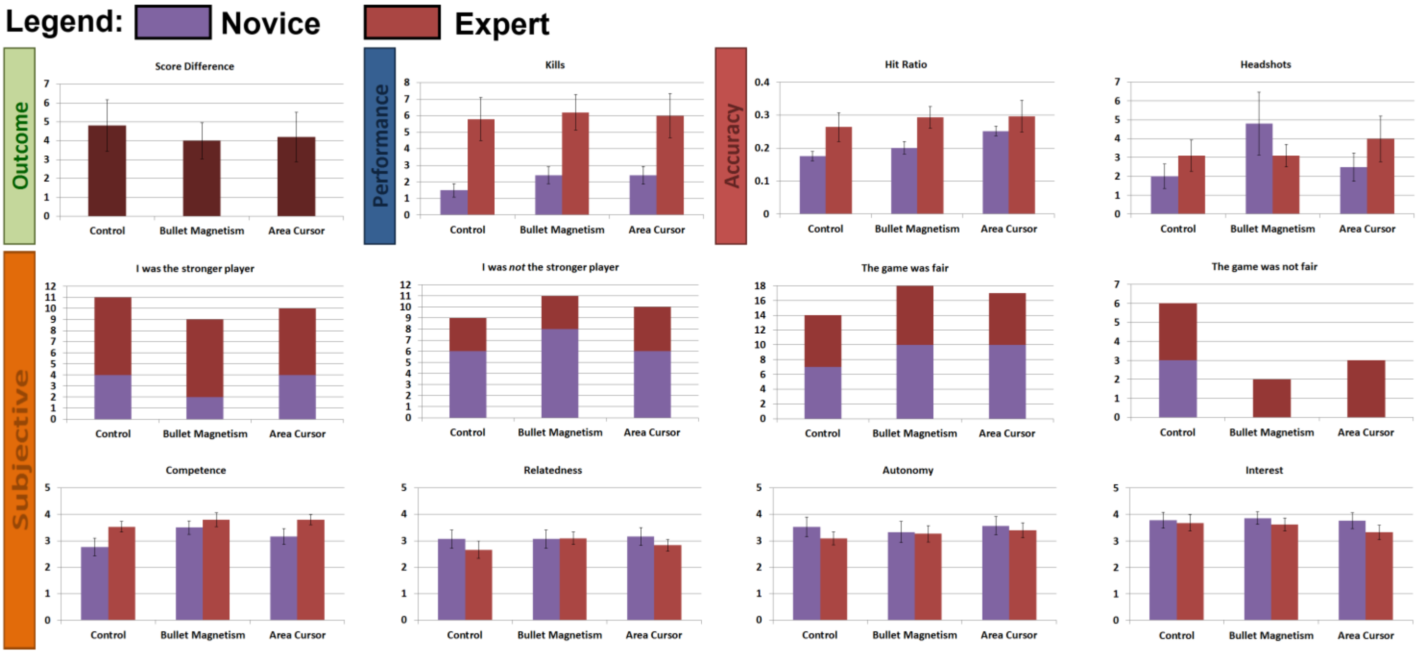

Fig. 2 Means (+- SE) for performance measures (top row) and experience measures (bottom row). Frequencies of responses for subjective questions (middle row).

on hit ratio ($F_{1,18}$=.961, p=.391) or any interaction between expertise and assist technique ($F_{2,36}$=.3.3, p=.085).

There were no main effects of assist technique ($F_{2,36}$=.969, p=.389) or expertise ($F_{1,18}$=.093, p=.764) on headshot ratio.

Performance: Experts had significantly more kills than novices ($F_{1,18}$=8.66, p=.009, η^2=.33); however, there was no effect of aim assist technique on kills ($F_{2,36}$=1.62, p=.212) or interaction of expertise and assist technique ($F_{2,36}$=.43, p=.654). Correspondingly, novices had significantly more deaths than experts ($F_{1,18}$=8.87, p=.008, η^2=.33); however, there was no effect of aim assist technique on deaths ($F_{2,36}$=2.3, p=.117) or interaction of expertise and assist technique ($F_{2,36}$=.43, p=.654).

Experience: There was a main effect of assist technique on perceived competence ($F_{2,36}$=8.66, p=.009, η^2=.33); pairwise comparisons show that participants felt more competent with Bullet Magnetism than control (p=.018). Although Area Cursor was perceived as yielding more competence than control, this result failed to reach significance (p=.070); there was no difference between area cursor and bullet magnetism (p=.390). There were no main effects of assist technique on relatedness ($F_{2,36}$=.652, p=.527), autonomy ($F_{2,36}$=1.2, p=.310), or interest ($F_{2,36}$=.859, p=.432). There were also no effects of expertise on competence ($F_{1,18}$=2.9, p=.101), relatedness ($F_{1,18}$=.35, p=.560), autonomy ($F_{1,18}$=.22, p=.642), or interest ($F_{1,18}$=50, p=.489).

Subjective: 10/10 (100%) novices stated that the game was fair when area cursor and bullet magnetism were used; 7/10 (70%) thought games without aiming assistance were fair. 7/10 (70%) experts considered the game to be fair when area cursor or no assistance was used; 8/10 (80%) thought that it was fair when bullet magnetism was used.

4/10 (40%) novices felt that they were the stronger player in games played with area cursor and no assistance and 2/10 thought that they were the stronger player when using bullet magnetism. 7/10 (70%) experts felt that they were the stronger player when bullet magnetism or no assistance was used; 6/10 (60%) experts felt they were the stronger player when area cursor was used.

TABLE I. Frequency of responses for "Was this round fair?" (Yes responses shown) and "Who was stronger?" (Me responses shown).

	Was this round fair (Yes)			Who was stronger (Me)		
	Total	Novices	Experts	Total	Novices	Experts
No Assistance	**14**	7	7	**11**	4	7
Bullet Magnetism	**18**	10	8	**9**	2	7
Area Cursor	**17**	10	7	**10**	4	6

A. Summary of Results

Aiming assistance helped the novices to improve their accuracy (although only area cursor reached significance) to the extent that differences were not observed between novices and experts on the accuracy measures; however, this did not translate into significant improvements in performance (in terms of kills or deaths). Aiming assistance also improved how competent players felt, although only bullet magnetism reached significance; no other experience measures showed significant differences.

The fairness ratings indicate that the majority of players found the games to be more fair when aiming assistance was present, but novices and experts mostly agreed that the expert was the stronger player.

VI. Discussion

The main findings from our study are:

- aiming assistance techniques led to an increase in accuracy for novice players (e.g., Area Cursor had a significantly higher overall hit rate for novices);
- however, this increased accuracy did not lead to significantly closer scores in the game (score differences were slightly reduced with assistance, but not significantly so).

In the following sections, we discuss reasons why the assistance techniques did not work as well as expected, and outline future studies that could use our results to develop more effective player balancing techniques.

A. *Why did Bullet Magnetism and Area Cursor not result in closer matches?*

Although Bullet Magnetism and Area Cursor helped users improve their accuracy, it did not translate into an increase in score for the novice player. From our observations of the matches, we see four possible reasons for this result – relating both to the assistance techniques themselves, and also to broader game issues that limited the amount of assistance that the techniques could provide.

1. *Inexperienced Novices* – Several of the participants had little previous experience playing FPS games on PCs – that is, they had played only a handful of times casually, or had only played FPS games with a game controller on consoles. These participants tended to be very unfamiliar with the game, leading to in-game behaviors that could not be aided by the assistance techniques. For example, if players are unfamiliar with the controls and spend the majority of their time controlling movement rather than taking shots at the other player, no amount of aim assistance will help. This shows that a balancing technique that only affects one aspect of gameplay (i.e., shooting) can be unsuccessful if that aspect is overshadowed by other activities (e.g., player movement).
2. *Novices got lost* – Novices also seemed to spend much of their time wandering around the map, and ended up getting lost frequently. They seemed to have difficulty building a spatial map of the level: during the sessions, several comments were made by the novices about being lost or about having difficulty figuring out where they needed to go. Experts, in contrast, seemed to build their spatial map immediately and then used that knowledge to efficiently move around the map. This result shows that there are several different elements in First-Person Shooters that differentiate experts and novices. Knowledge of the map, movement patterns, and other factors are also important part of success in FPS games, none of which are aided by aim assistance.
3. *Insufficient levels of assistance* – although the levels of assistance worked well during pilot testing and in previous studies [25], the levels in the dynamic system did not appear to be strong enough to balance real world situations. One of the problems is that the dynamic adjustment system took time to come into effect, and by the time it started to provide a substantial level of assistance, novices were often so far behind they couldn't catch up. This suggests that more aggressive adaptation is needed in dynamic balancing, at least for short games.
4. *Health packs* – the map had several health packs that allowed players to repair damage done by the other player. These packs respawned fairly quickly, so it was possible for a player to memorize their locations and use them to substantially extend their endurance in a firefight. This strategy was employed by most experts: after an intense firefight, experts would make sure to heal up to full health before reengaging the novice. Novices, in contrast, would not actively look for health packs after a firefight, and therefore would be at a disadvantage when they next encountered the (fully healed) expert. This result shows again that there is more to expertise in real-world FPS games than just shooting accuracy.

Overall, our results show that a player-balancing scheme for a real-world First-Person Shooter game will need to take into account more of the game elements that differentiate novices and experts – including, for example, development of spatial knowledge, movement abilities, and strategies for using resources in the game world. A balancing scheme can only assist performance when certain actions are occurring, and if these do not occur often enough, the scheme can be prevented from ever being successful.

VII. Future Work

Although our study did not balance game outcome, it has provided useful insights into the factors that affect balancing in real-world FPS situations. Our future studies in this area will investigate the four reasons for poor balancing performance discussed above. We will carry out further experiments with modified versions of our game to test each hypothesis. First, health packs will be removed or their respawn times will be significantly increased. Second, assistance levels in our dynamic system will be increased, and we will test a static system with a high level of assistance. Third, we will provide a minimap of the level to both players in one of the corners of the screen, similar to what other games provide, in order to equalize spatial knowledge of the map. Because our ultimate goal is to balance players with a wide range of expertise, we will see if these changes are enough before exploring balancing with intermediate and experts users.

Another promising area of work is to look at alternative balancing mechanisms that cover other aspects of expertise in FPS. For example, a system could give the weaker player a map showing the locations of all players, or could give them more powerful weapons, or faster heal times. These alternate schemes could be used together with aim assistance to provide significant advantage to a novice player.

Finally, we are also interested in investigating the performance of aiming assistance with other input devices such as game controllers, since previous work in 3D aiming assistance has only investigated how well techniques work with mice. Different control mechanisms in different controllers may have effects on the benefits of aim assistance.

VIII. CONCLUSION

First Person Shooter games are very popular. Competition is a big part of First Person Shooter games, but it brings complications when trying to achieve game balance. Weaker players get frustrated and strong players get bored with the lack of challenge if the skill levels of the players differ. Several approaches have been developed to achieve balanced games; however, none have been shown to work well. A recent approach is aiming assistance, which has been effective in 2D environments to balance gameplay and has been used in 3D to improve performance of single players. Together, previous results suggest that aim assistance could be a good mechanism to use in 3D environments to increase enjoyment for all parties. However it's not clear if aiming assistance in a 3D game would work as well as a 2D game, because 3D games have more complex game elements involved.

The study carried out in this paper investigated whether aiming assistance could be an effective tool for balancing games. To do this, we investigated two aim assistance techniques, Area Cursor and Bullet Magnetism in a competitive two-player FPS game developed with the Unreal Development Kit. Participants were split into novice and expert pairs and played a deathmatch game with the aiming assistance techniques and with no assistance. We found that the techniques managed to increase accuracy and competence ratings of the novices, but they had no effect on game outcome or performance measures, and also had no effect on the enjoyment of the game as a result. Our study is the first to investigate aiming assistance for gameplay balancing in 3D FPS games, and our initial results suggest that improving the aiming accuracy of novice players is only the first step in effectively balancing multiplayer FPS games.

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